Visual Representations of Flow Data

and the Value of Visual Language

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Space and Naval Warfare Systems Center, San Diego

Report Documentation Page

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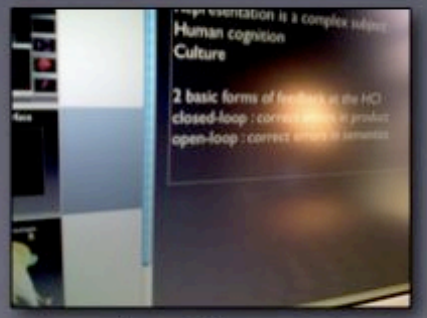
Human-Machine Efficiency

Over-Learned: **Feedback**

non-volitional feedback

haptic

volitional feedback



visual / aural

Human-Machine Efficiency

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correct errors in **production**

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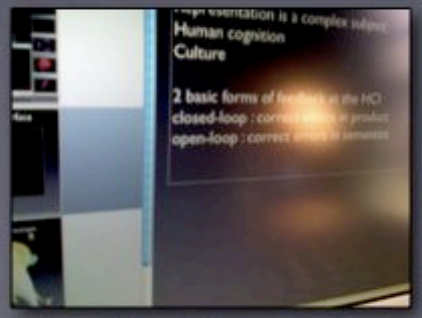

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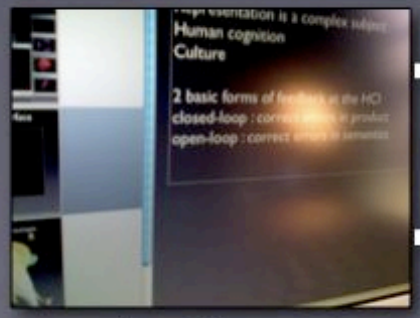


visual / aural

correct errors in **semantics**

Human-Machine Efficiency

Over-Learned: **Feedback** - haptic vs visual/aural

Haptic Feedback

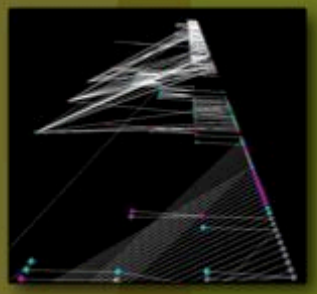
Visual / Aural Feedback

Sequential access

iFeel™

Sidewinder™
Force Feedback

Falcon™

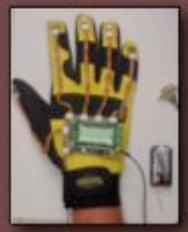


joystick

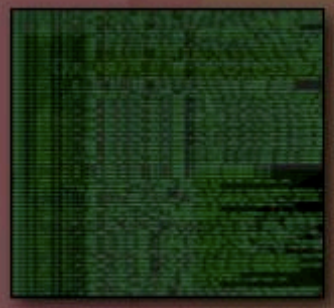
mouse

Random access

keyboard



data/gesture glove



multi-touch

voice control

Human-Machine Efficiency

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Visual / Aural Feedback

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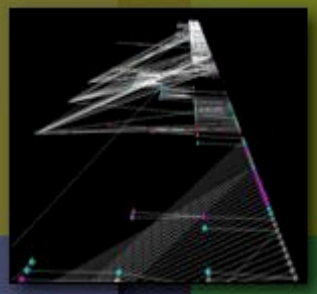

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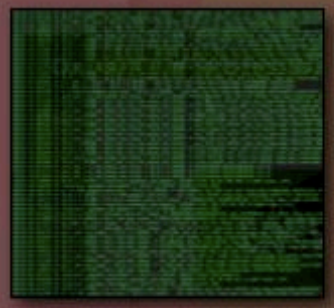

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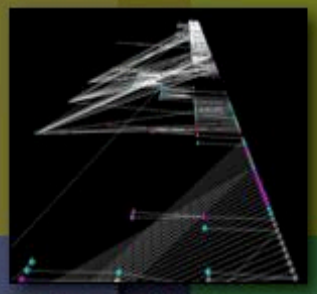

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mouse

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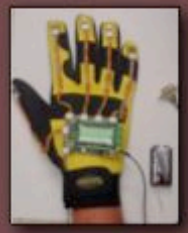
keyboard



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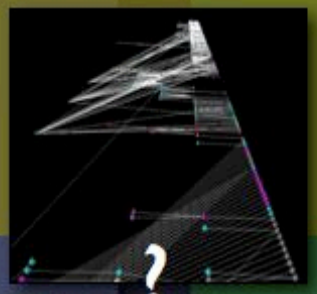

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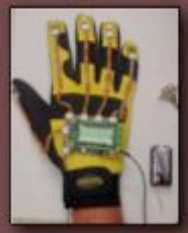


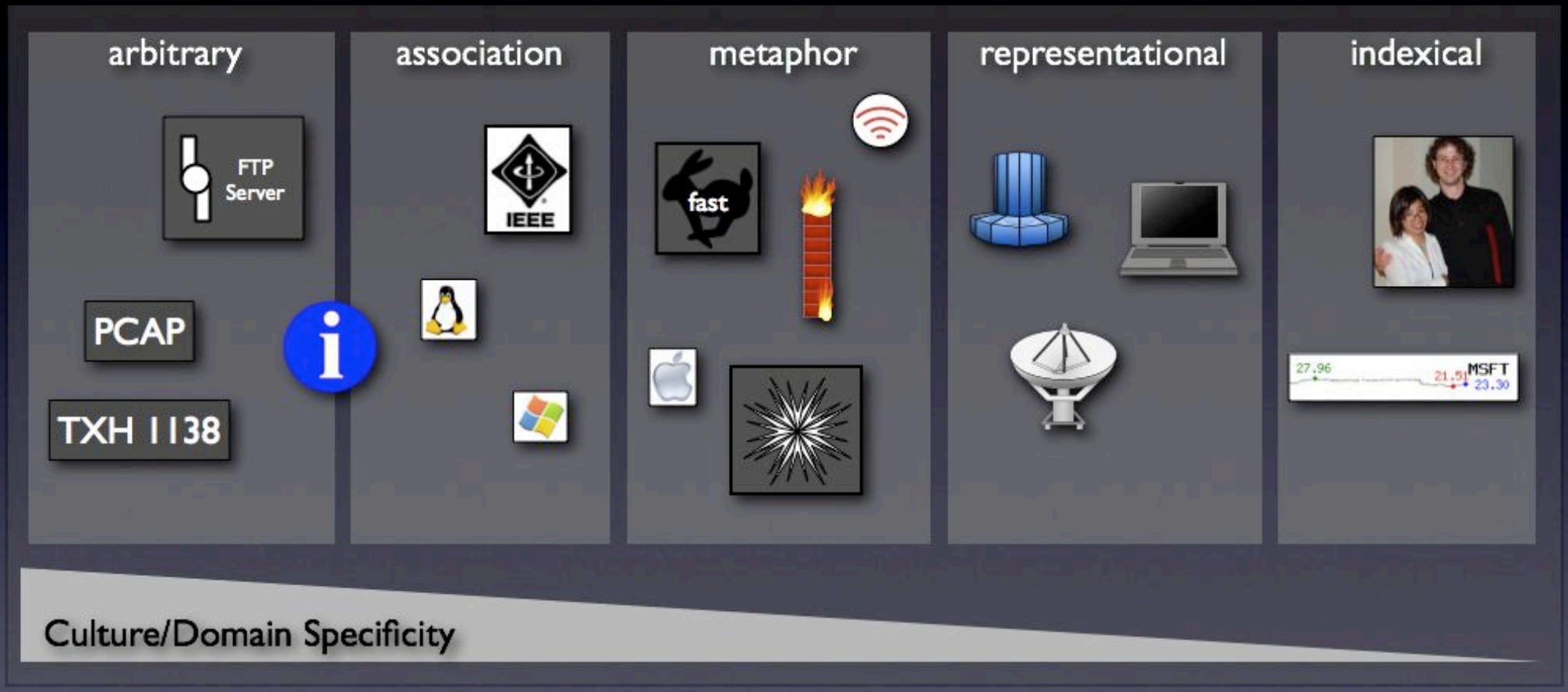
data/gesture glove

multi-touch

voice control

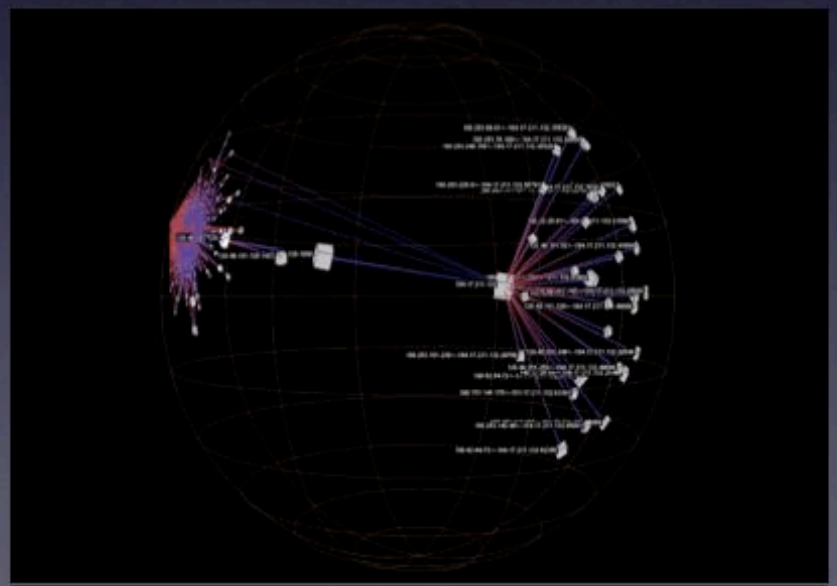
Human-Machine Efficiency

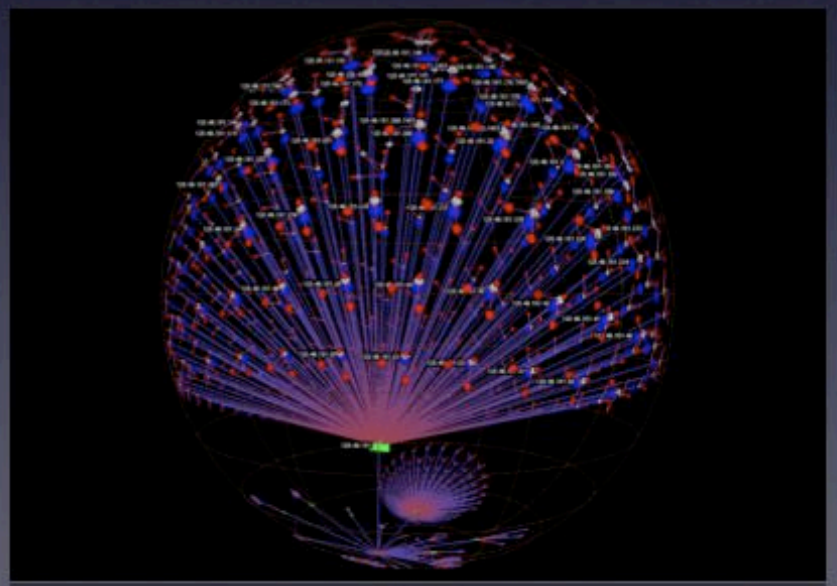
Under-Learned: **Representation**

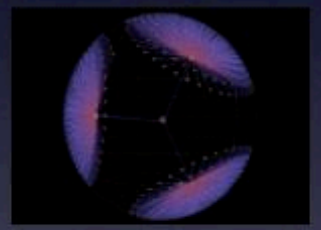


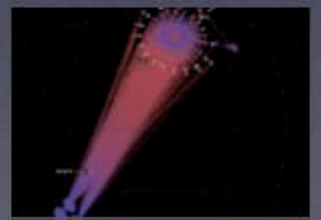
Flow in hyperbolic space

- 3 month SSC project in 2002
- discover and apply network visualization tools
- **Hyperviewer**: quasi-hierarchical hyperbolic space
- '**fish-eye**' 3-d
- Created by Stanford researcher **Tamara Munzner**



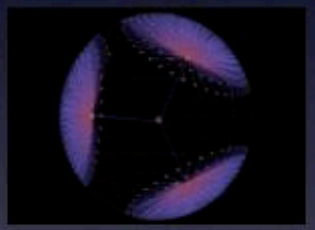


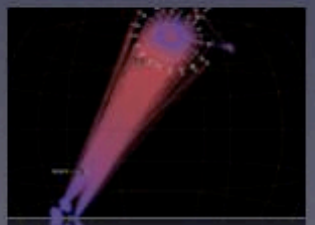




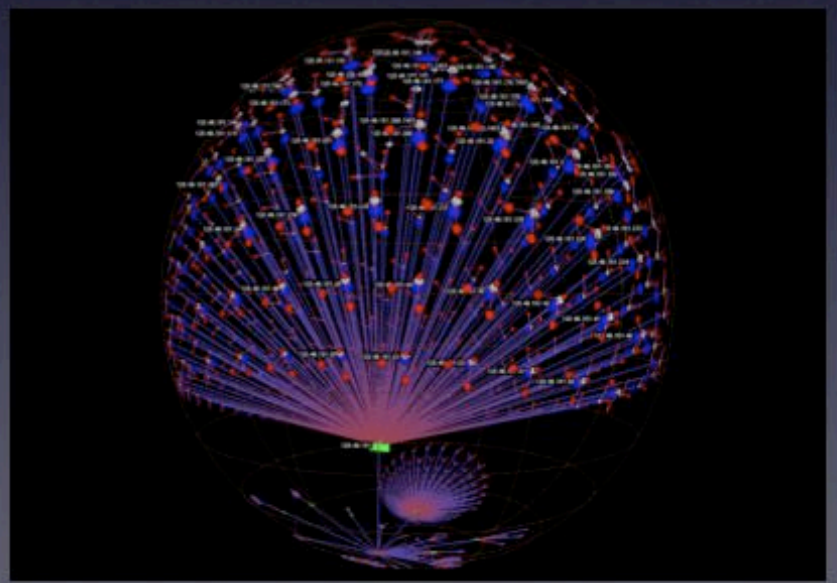
Flow in hyperbolic space

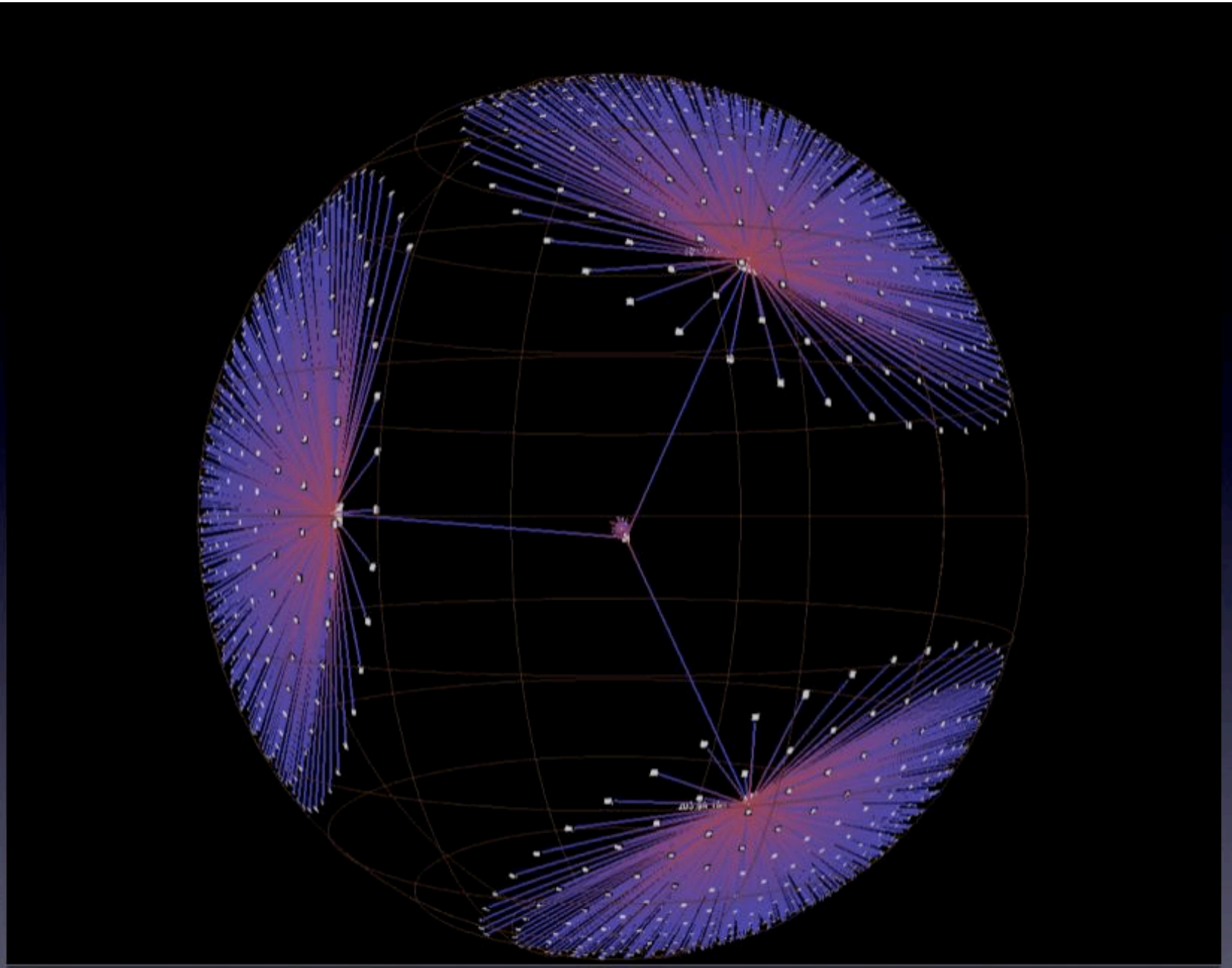
- Easily adapted to a forced-hierarchy view of flow
- **Opensource** C++ library and UI
- Experimented with visual methods



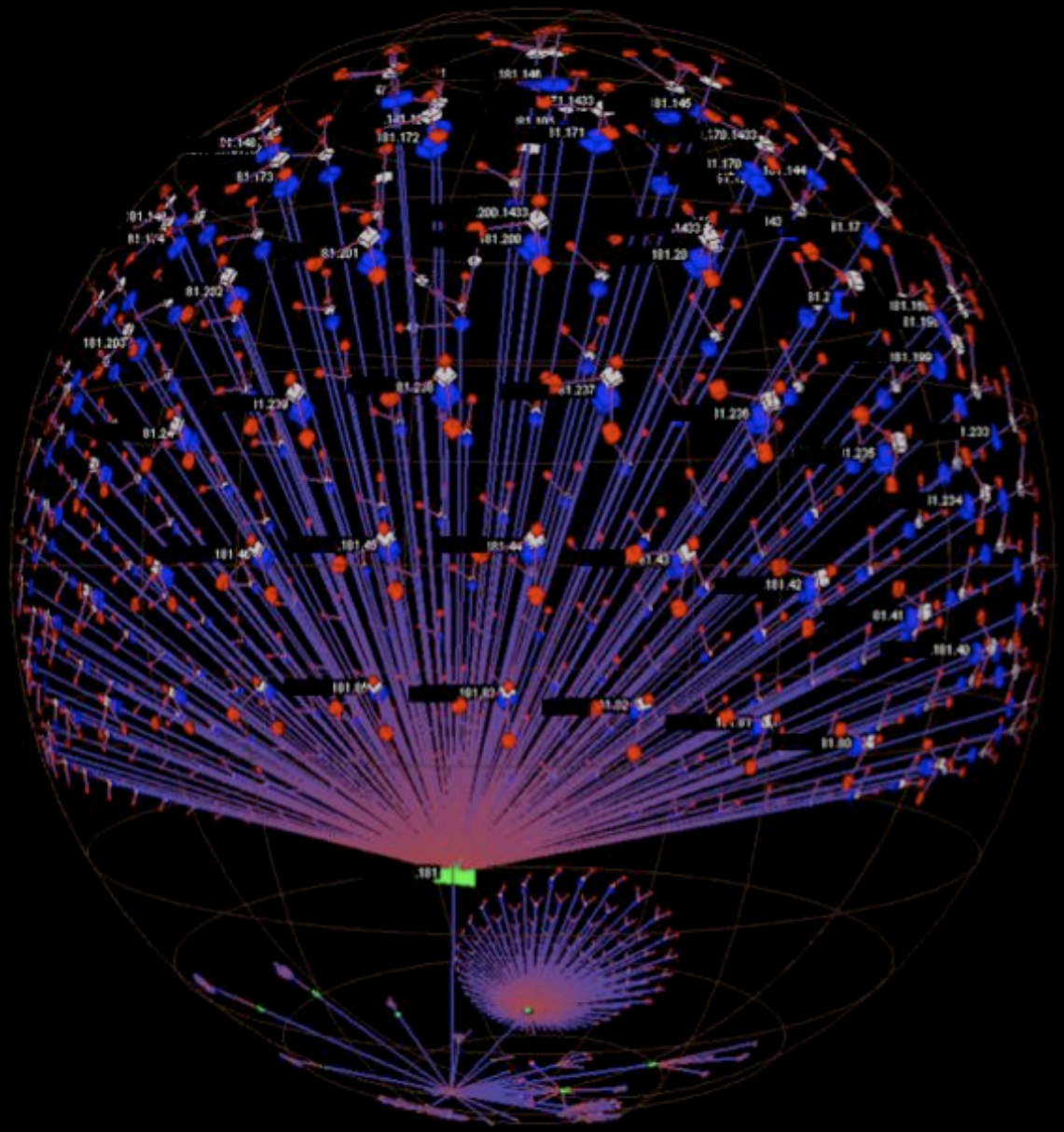


- colors
- graph cycles
- scaling
- text labels
- **graph size**
- search automation

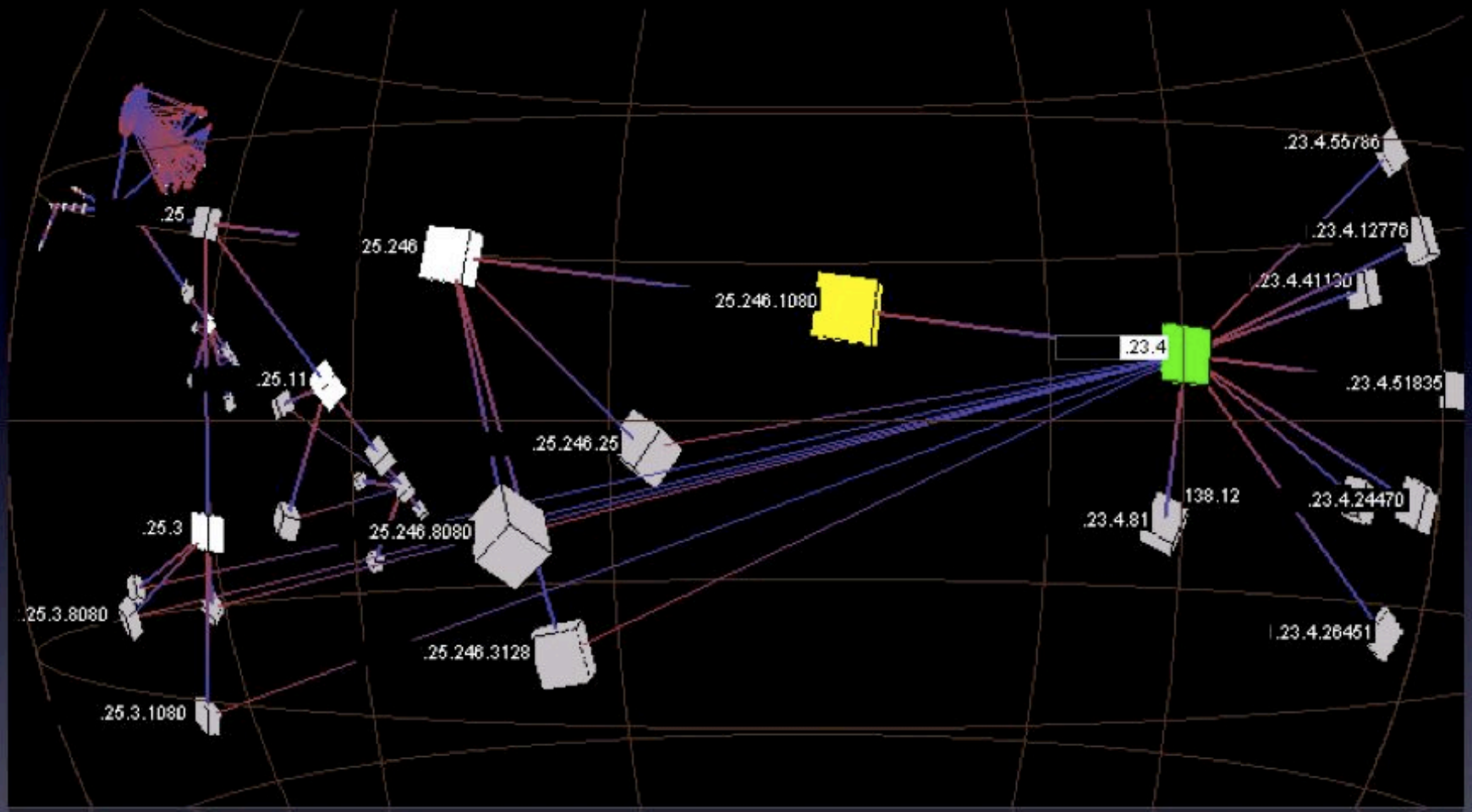




Symmetry in port access from 3 separate clients.



src/dst ports colored red/blue



Hierarchy showing client subnet and server ports

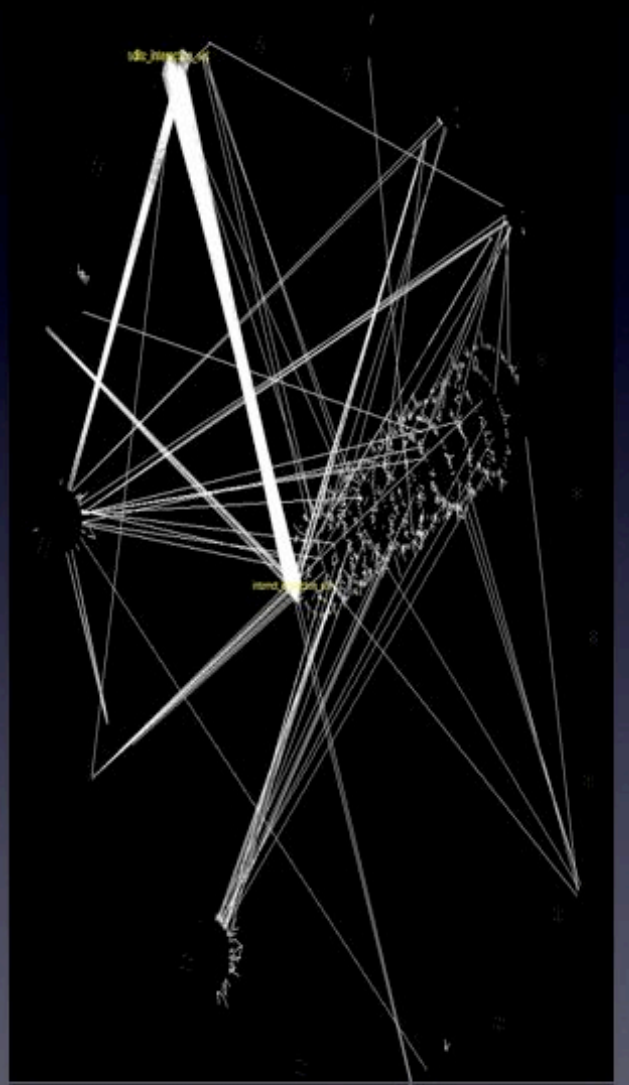
Shapes Vector

- Acquired by DARPA in 2002
- Developed by Australian DSTO

  (Defence Science Technology Organisation)
- JTF-GNO pilot program from 2003-2006

What is it?

- Intelligent Agents gather information and produce inferences
- Gathers information from multiple sources
  - pcap, flow, Snort, syslog, etc
- IAs performs automated data correlation & knowledge extraction
- Integrates visual and command-line analysis
- Integrated visualization makes use of human vision
- Supports visual analysis and decision-making



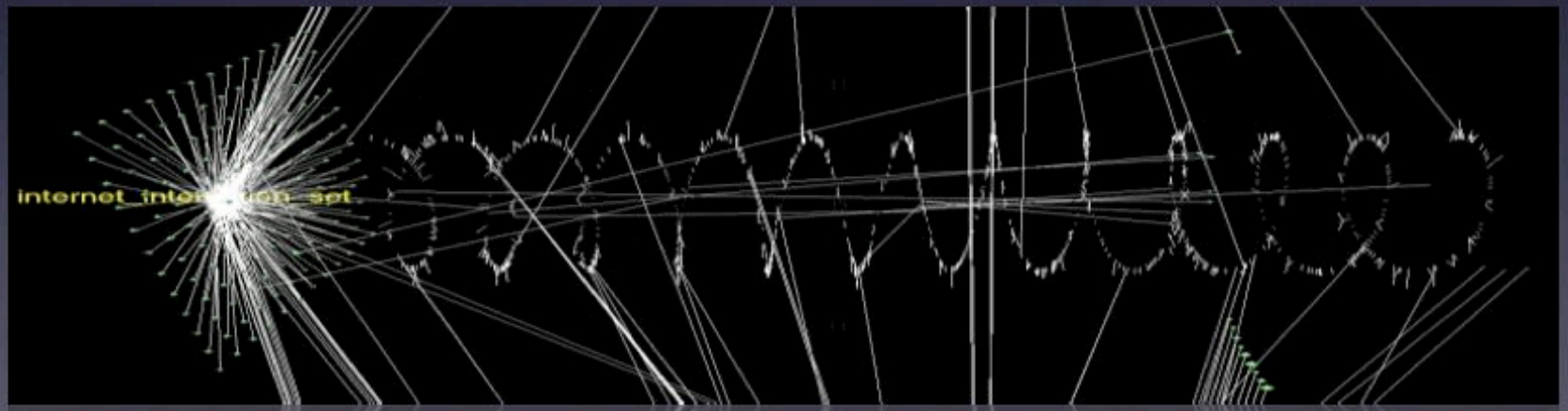
Shapes Vector

Contextual spatial, temporal, social, topological

Spatial physical geography or metaphor

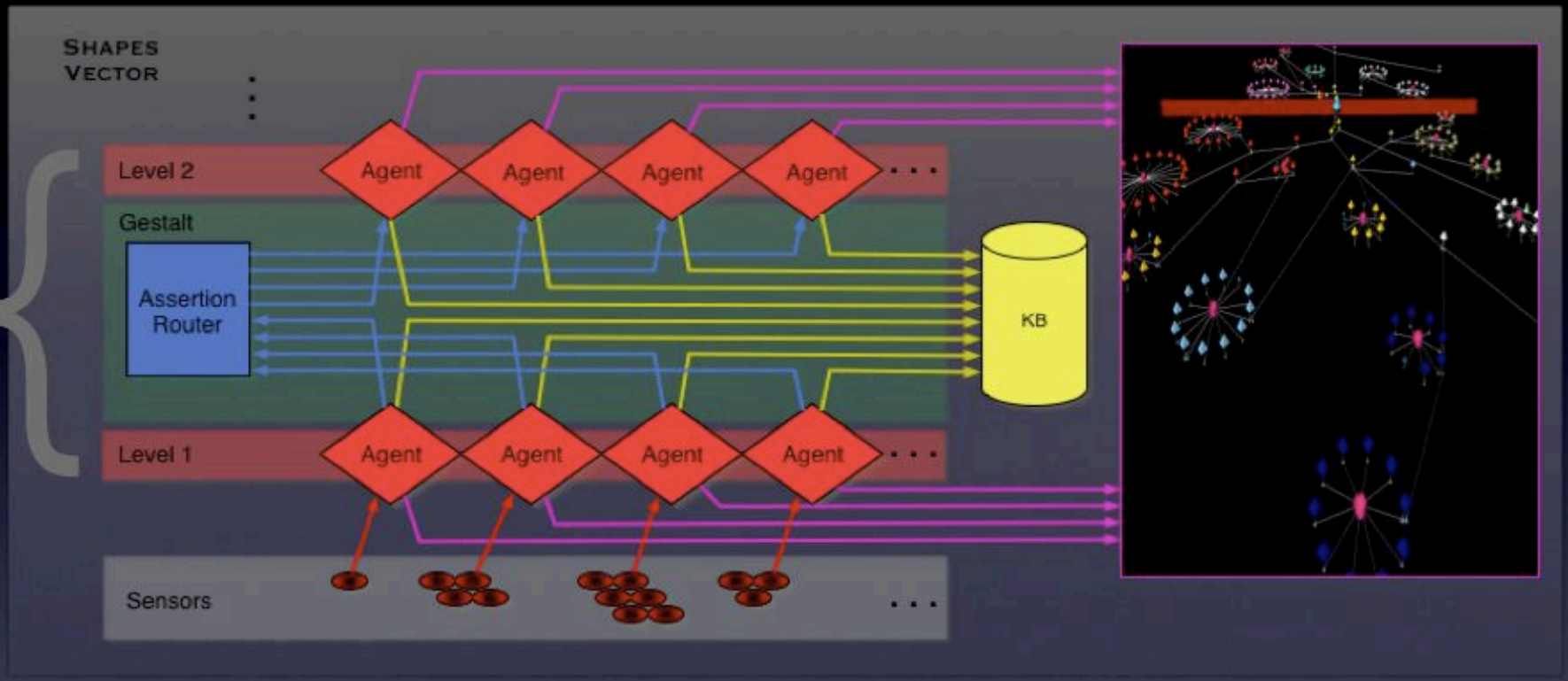
Temporal sequences in time, correlated

Visual use visual language to depict objects & events

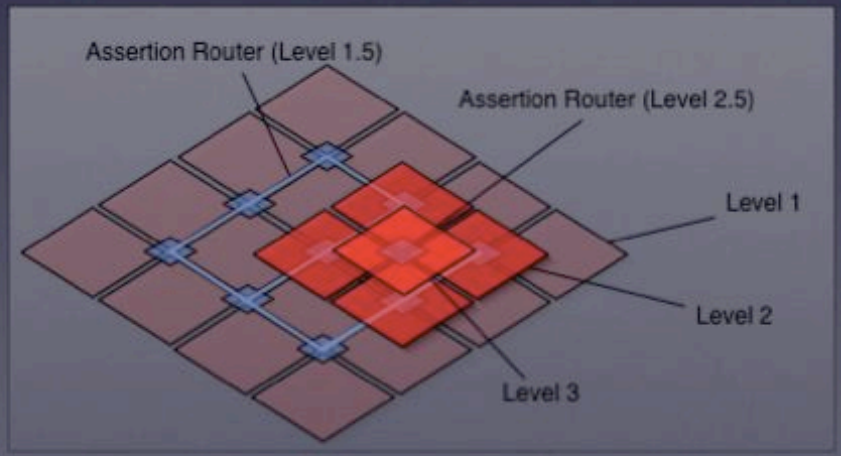


Architecture

SVKA



SVKA



- Agents can be written in many languages - must conform to the SV ontology and knowledge architecture (SVKA) specification
- Sensors can be built to wrap many information sources - must produce SV ontology
- SV ontology is a knowledge description language for network defense

Shapes Vector - Visual Language

- Easily defined visual mappings
- No applied theory of visual language

shape/color/scale

texture/icon

connection / topology

movement

packet events, information exchange, attribute changes, attribute values, host id, software, processes, machine purpose, network topology, social topology, intrusion events, event type, event priority, client vs server, routing, ...

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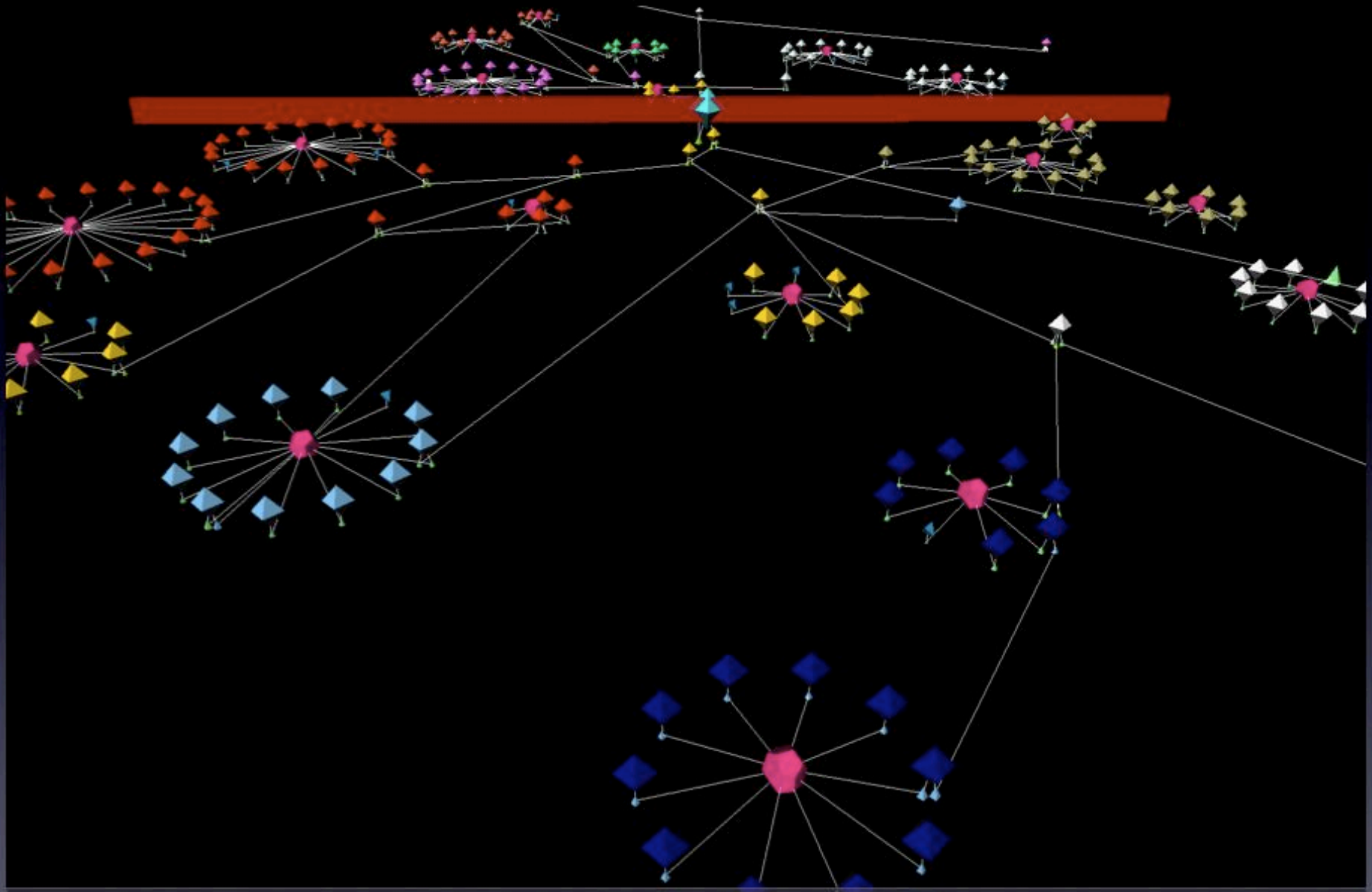
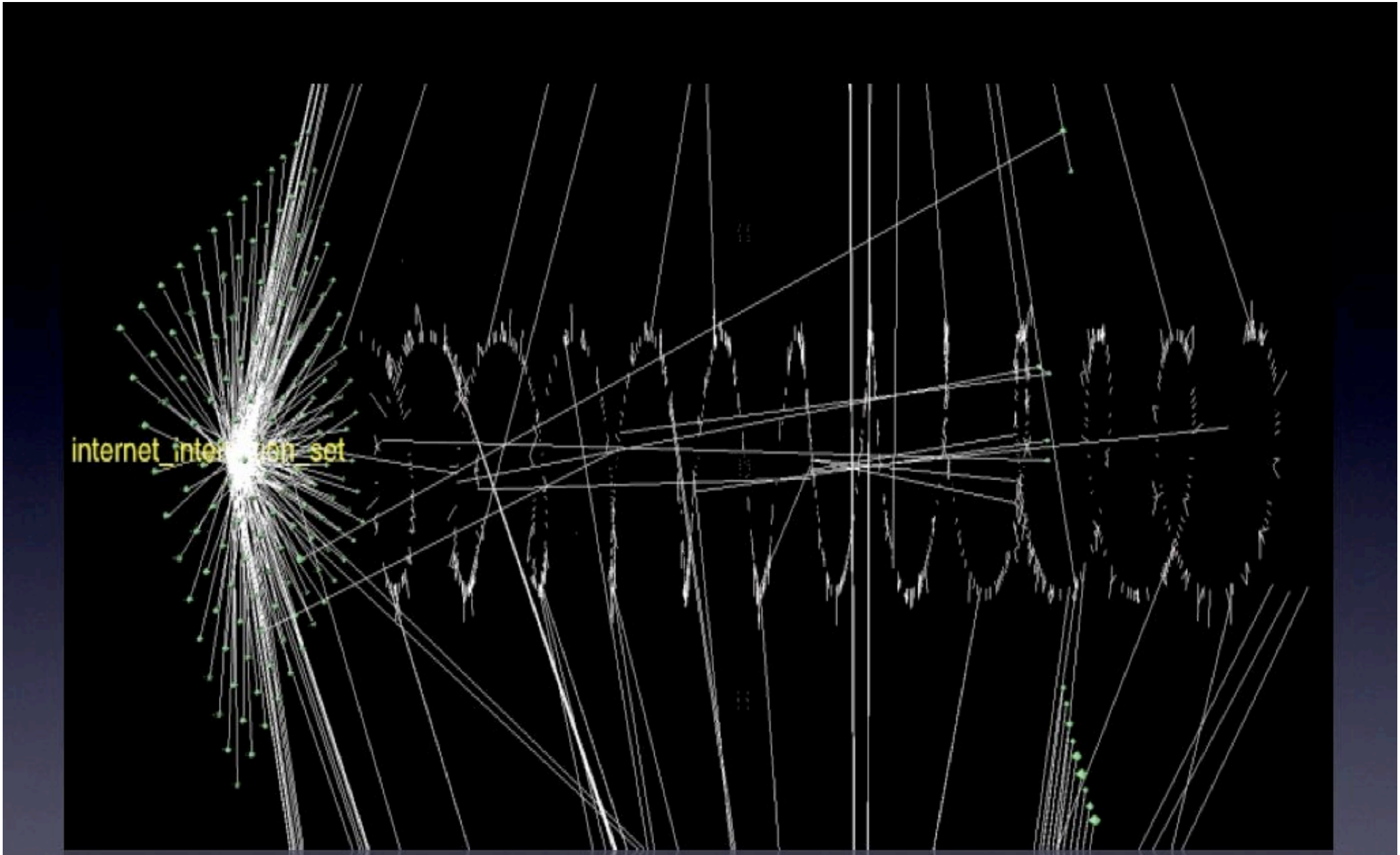
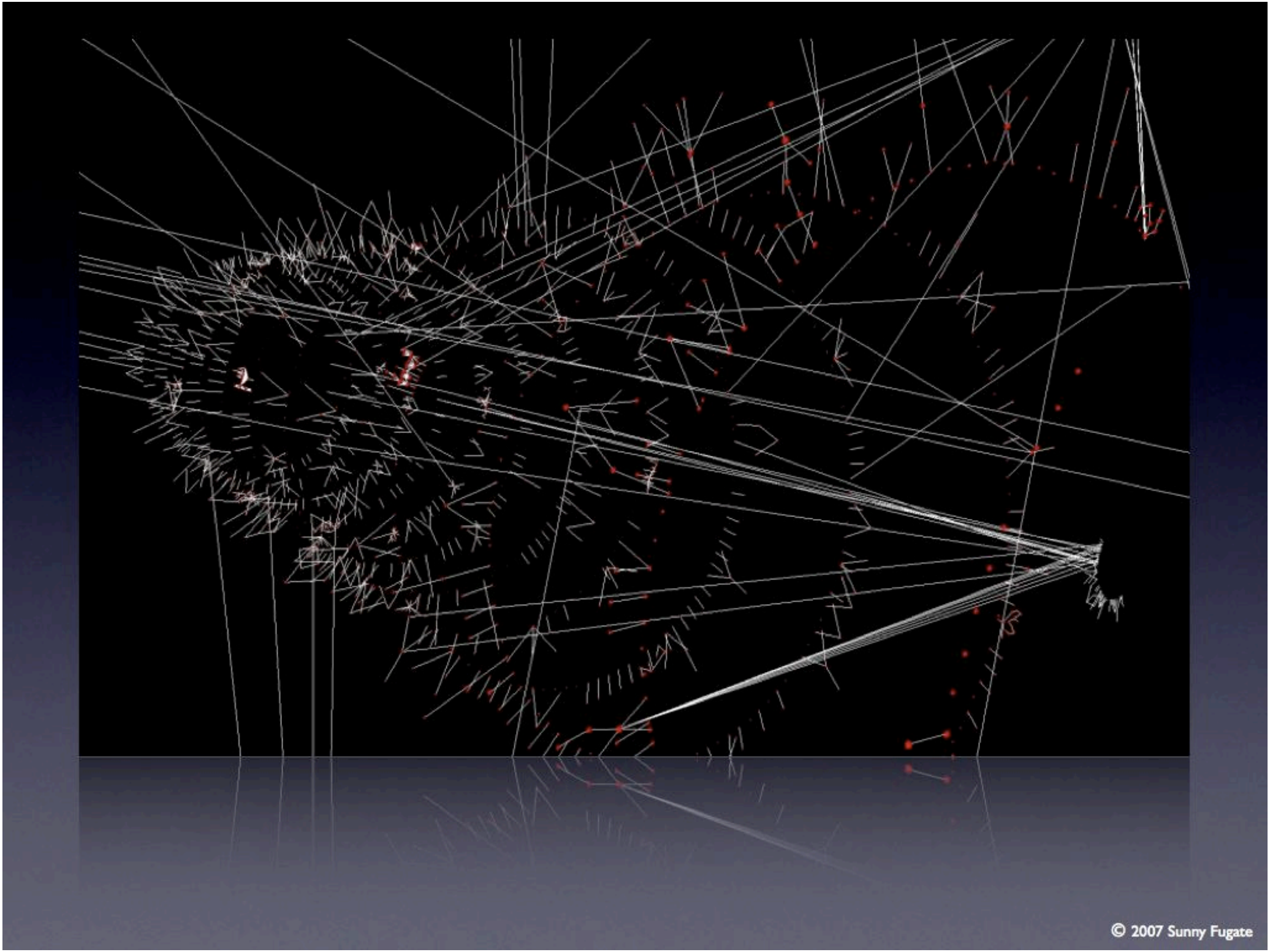


Toplogical layout using visual demarcations
(e.g. firewall, network segment, physical layout)



Automated layout to arrange hundreds of sub-graphs in a non-overlapping manner.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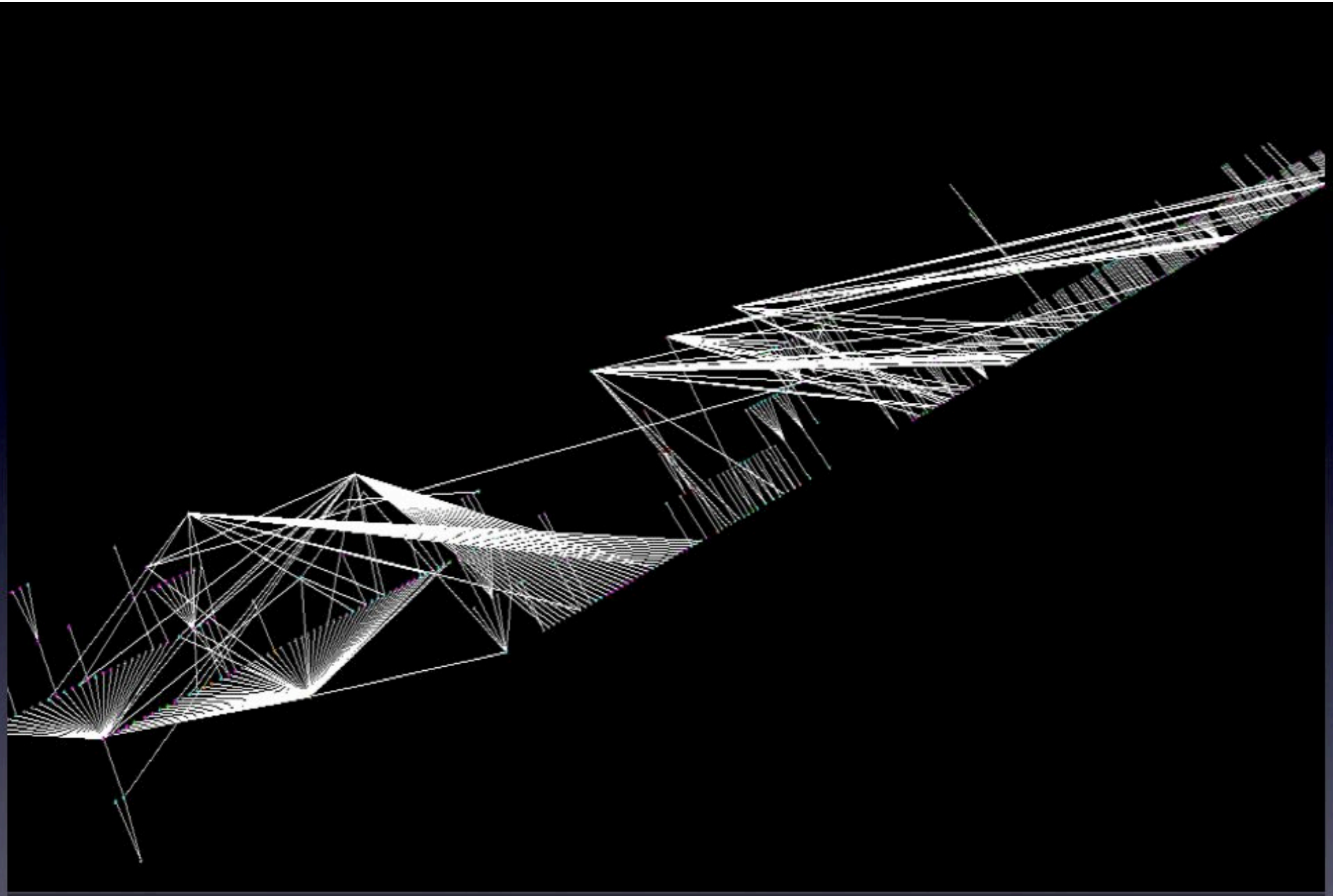
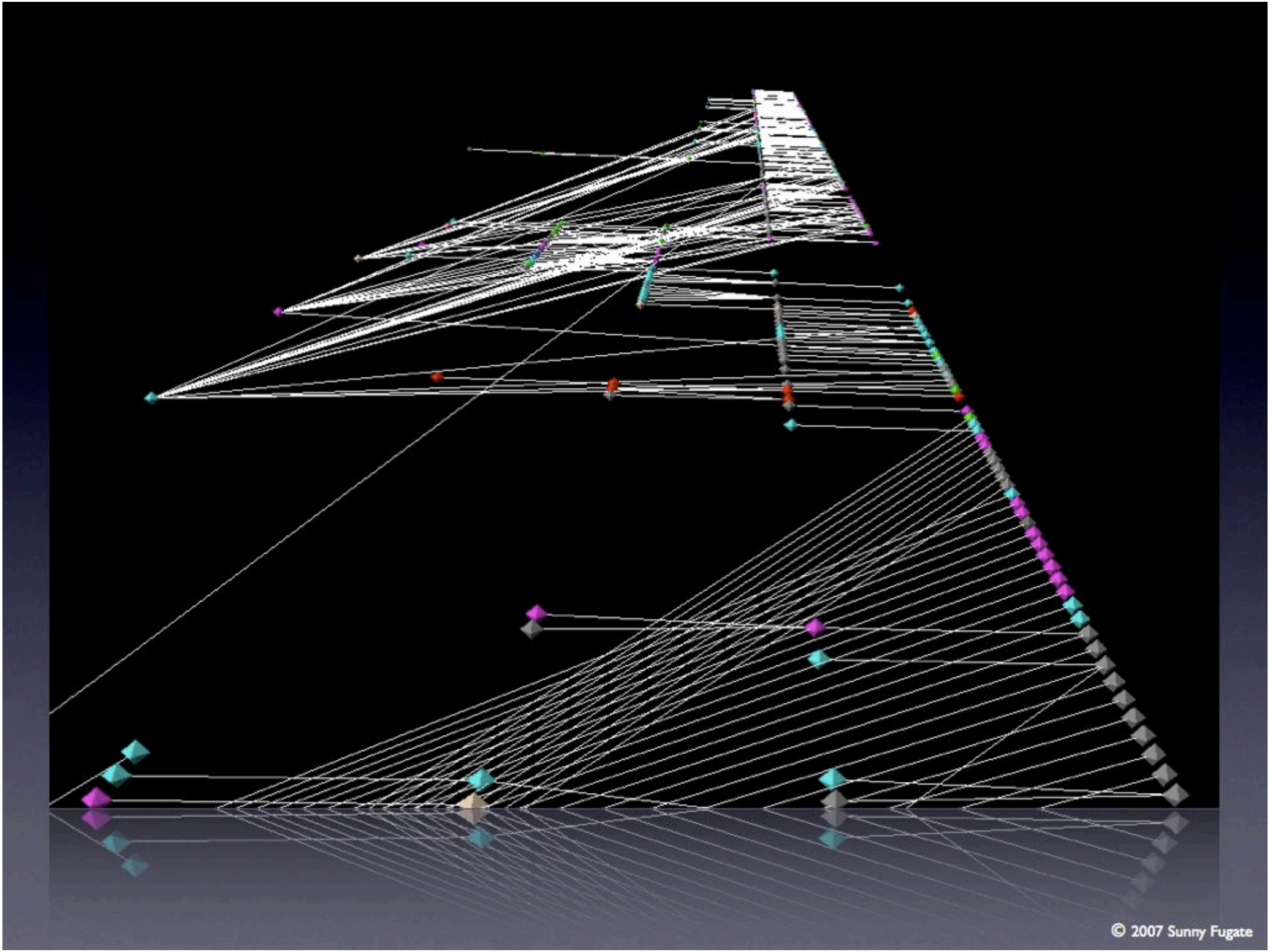


Topological layout discovered using hints in the data (e.g. TTL)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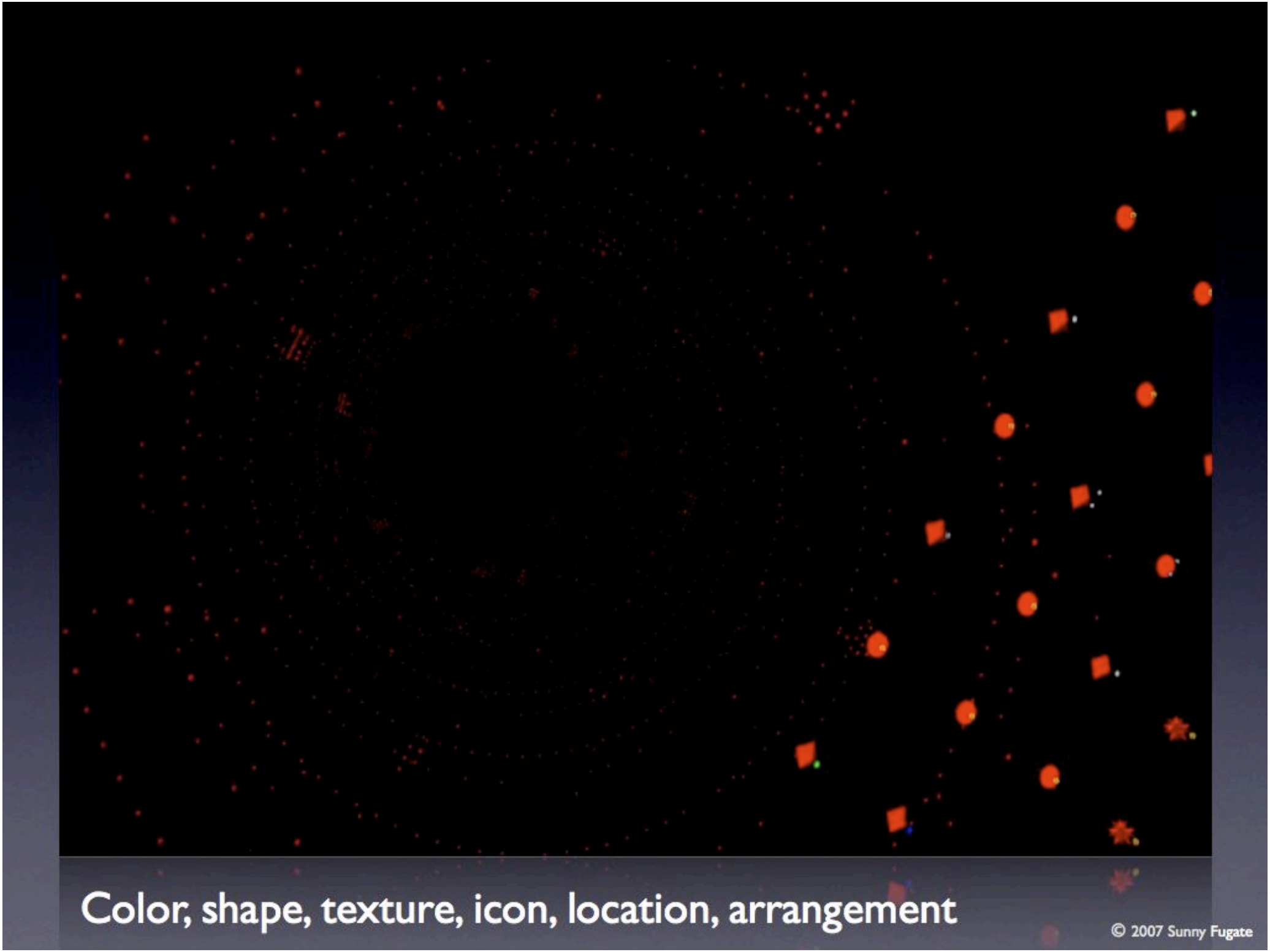
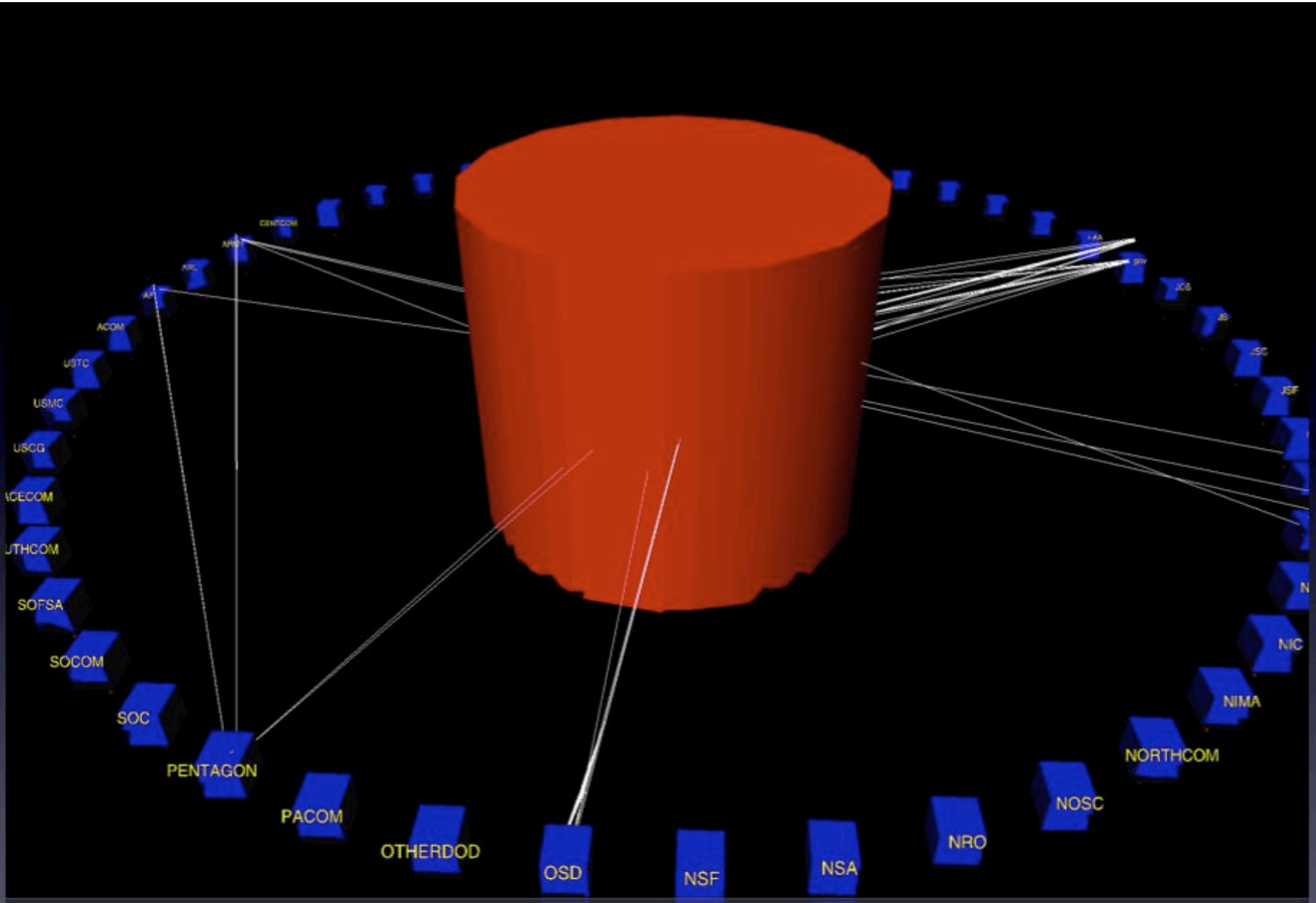
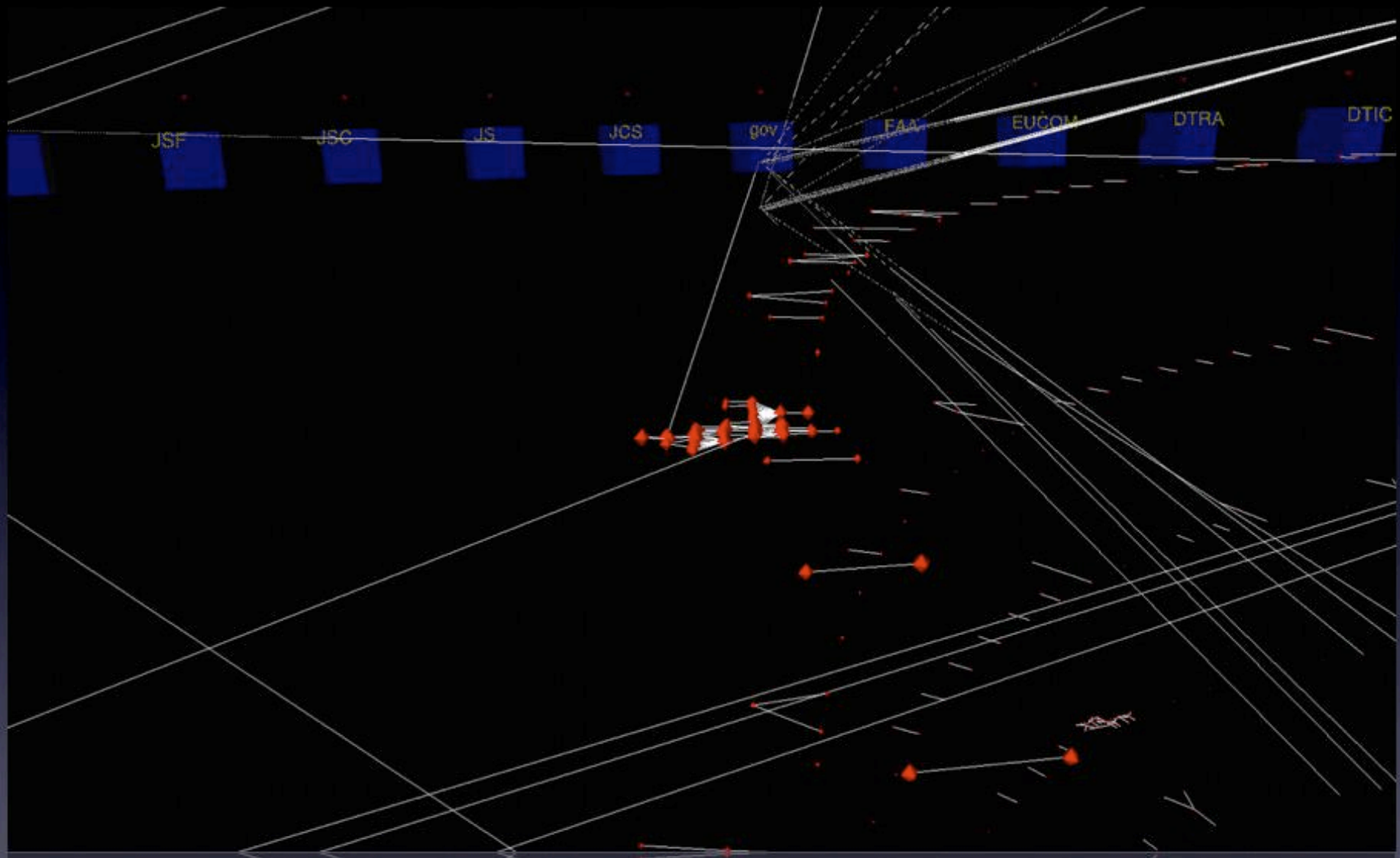




Visual grouping, demarcation, and detail-hiding



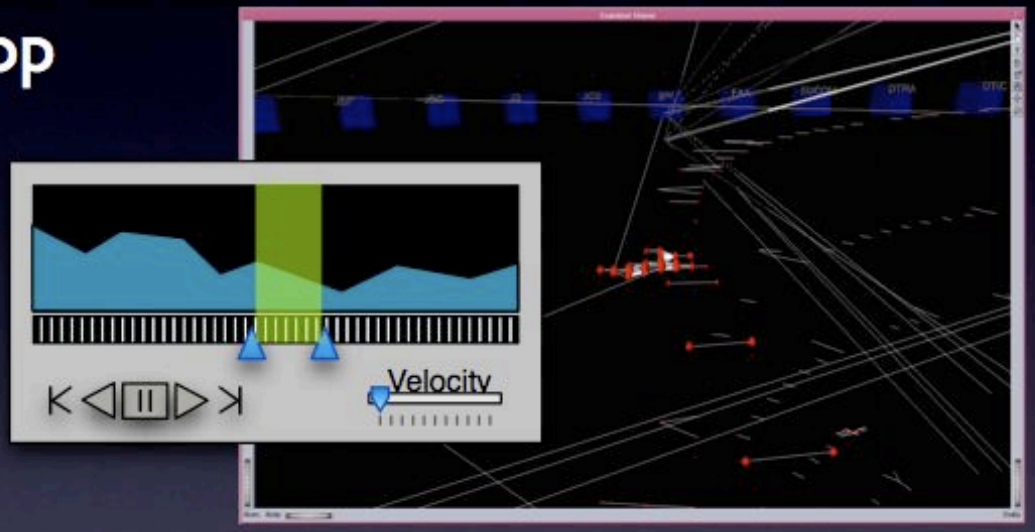
Expansive vantage points for network analysis

Shapes Vector Flow Viewer

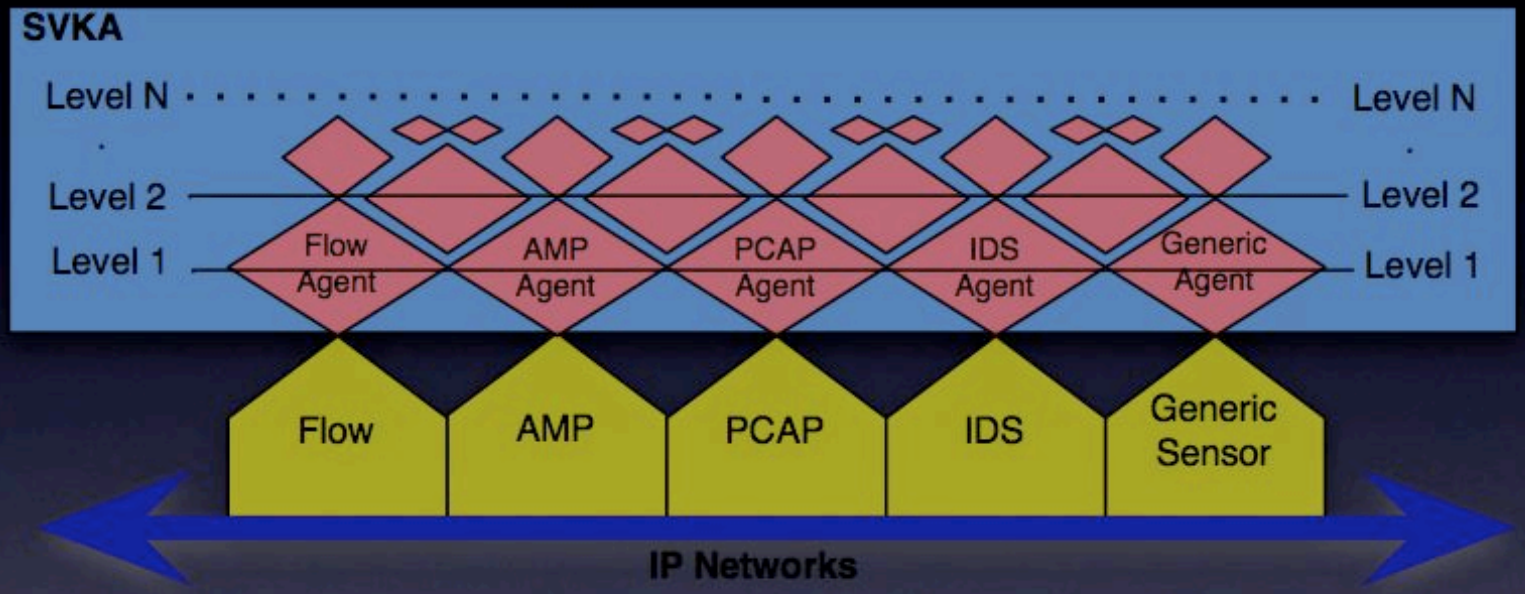
- JTF-GNO funded effort to implement SV
  - Use SV architecture and components
  - DARPA demo system > operational system
  - New scripts, sensors, agents, and GUI
- Results
  - A visual augmentation of CLI
  - Produces a view of social topology
  - Intuitive view of gobs of data
    - static topology and event replay
  - Links statistical views and topology view

Flow Viewer GUI

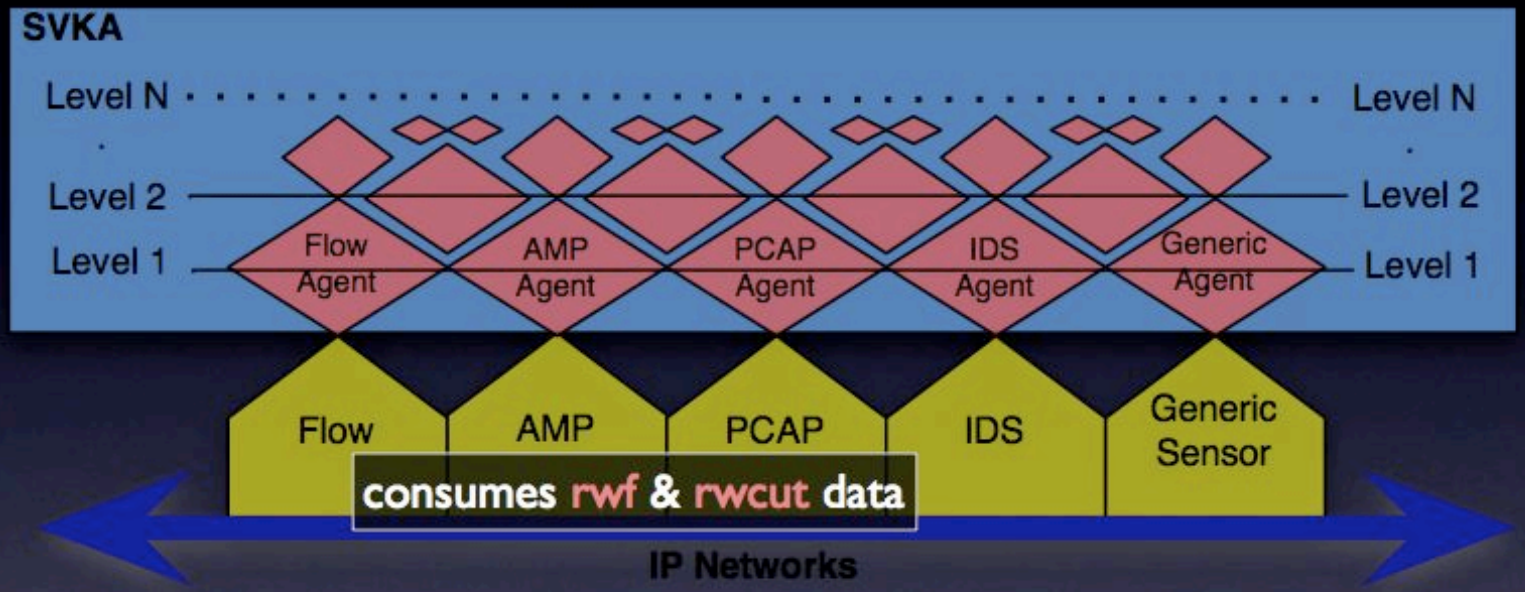
- multiple stats views linked to visuals
- playback specific ranges & loop
- adjust replay velocity
- time-skip
- IP and attribute hotlists
- dynamic filtering controls
  - GUI managed rwfilter
  - filter using SV ontology
- integration between flow, AMP, IDS, & PCAP



Flow Viewer Sensors



Flow Viewer Sensors



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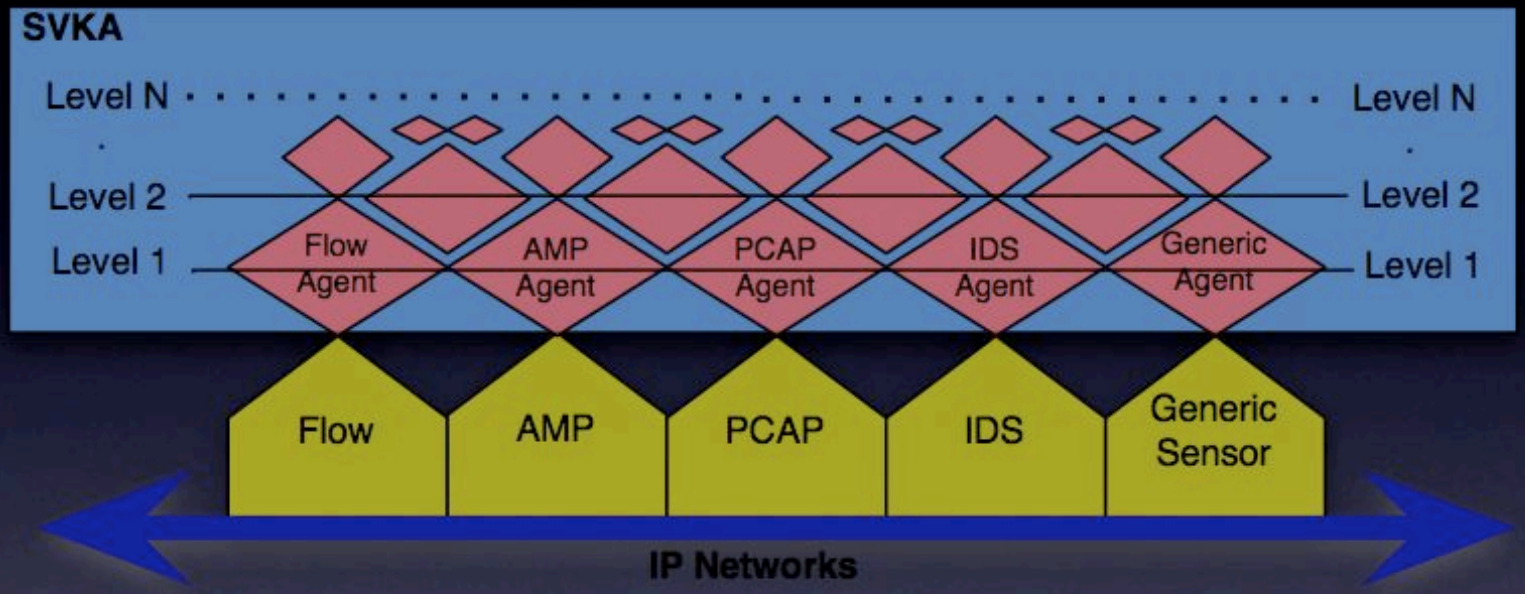
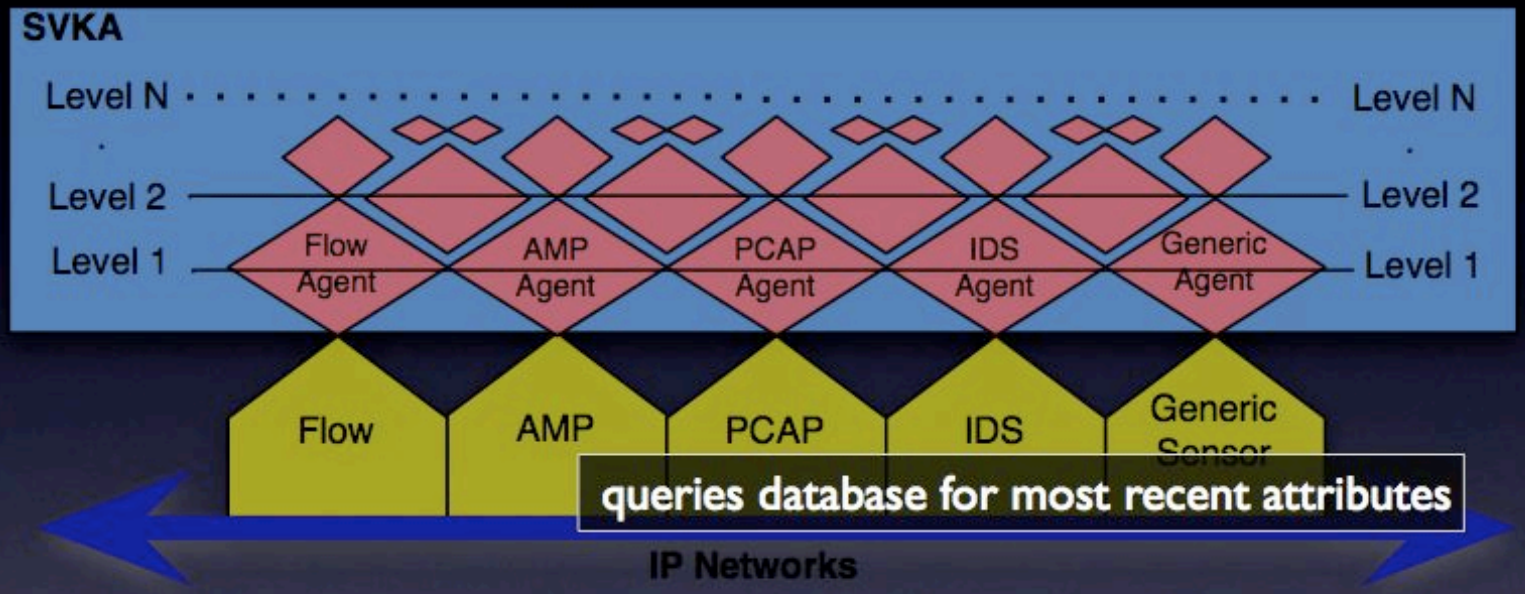


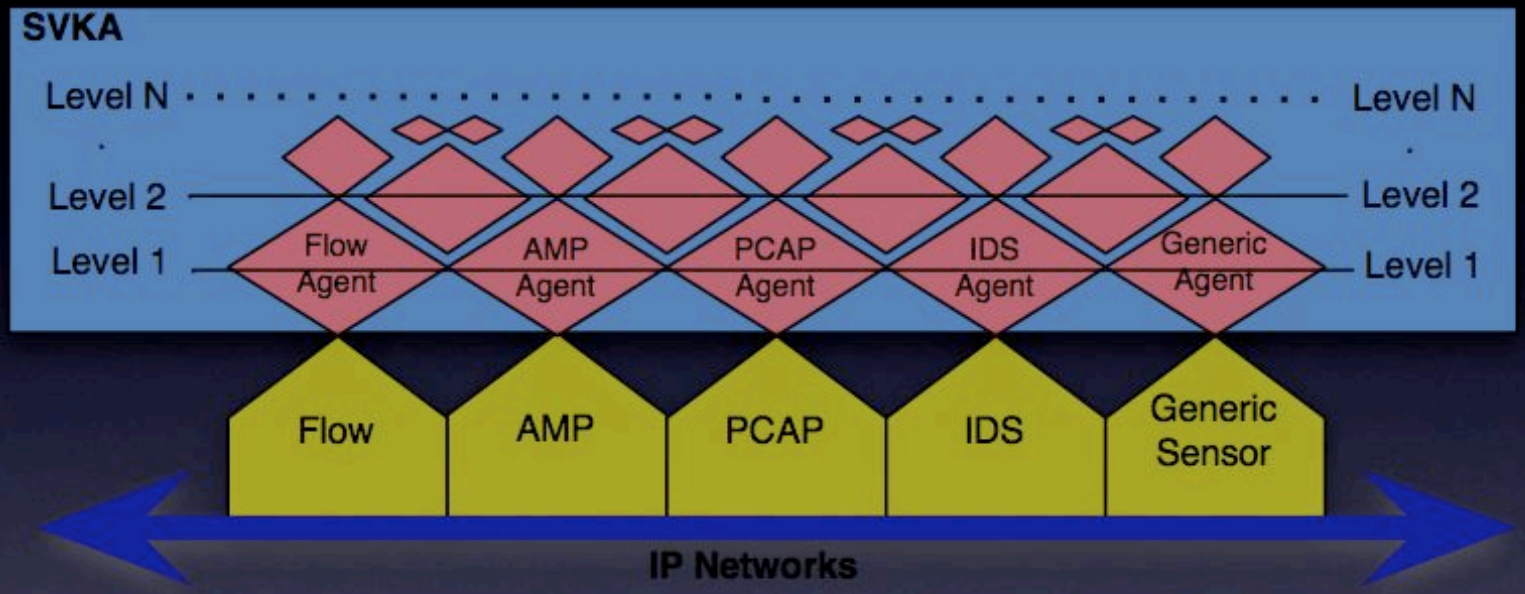
Flow Agent | consumes rwf & rwcut data

Flow Viewer Sensors



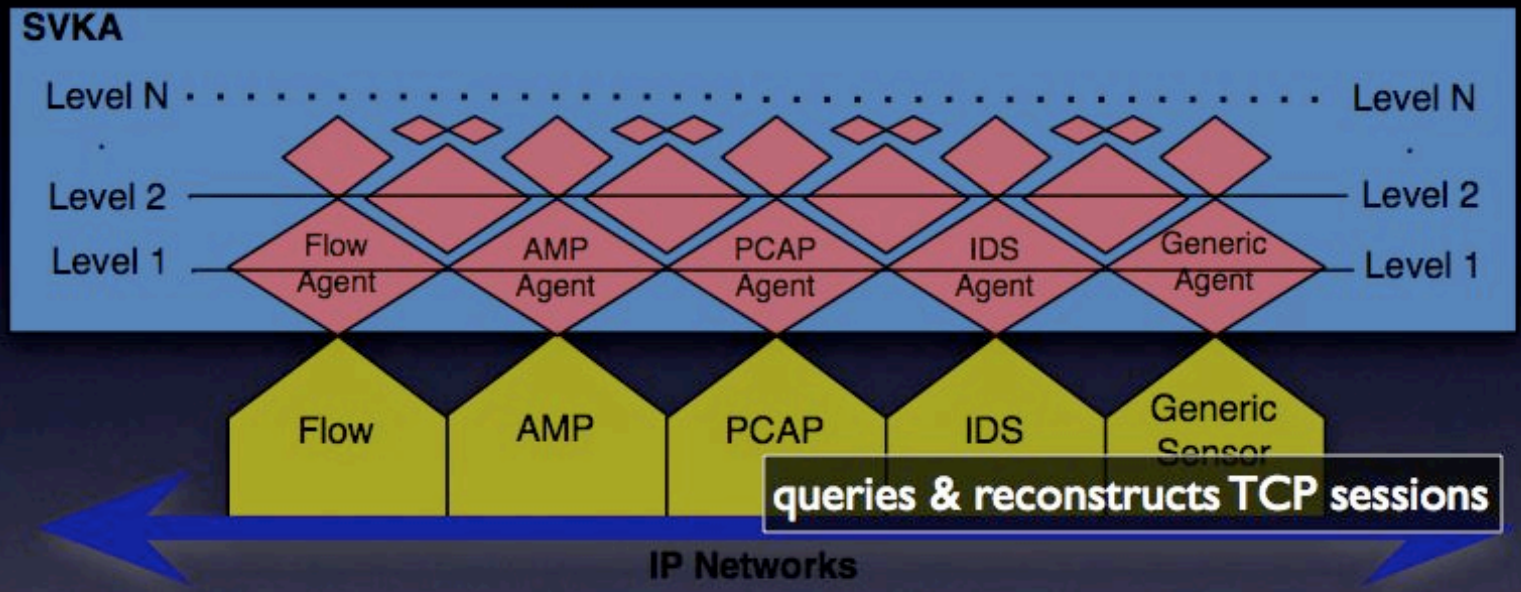
Flow Agent | consumes rwf & rwcut data

Flow Viewer Sensors



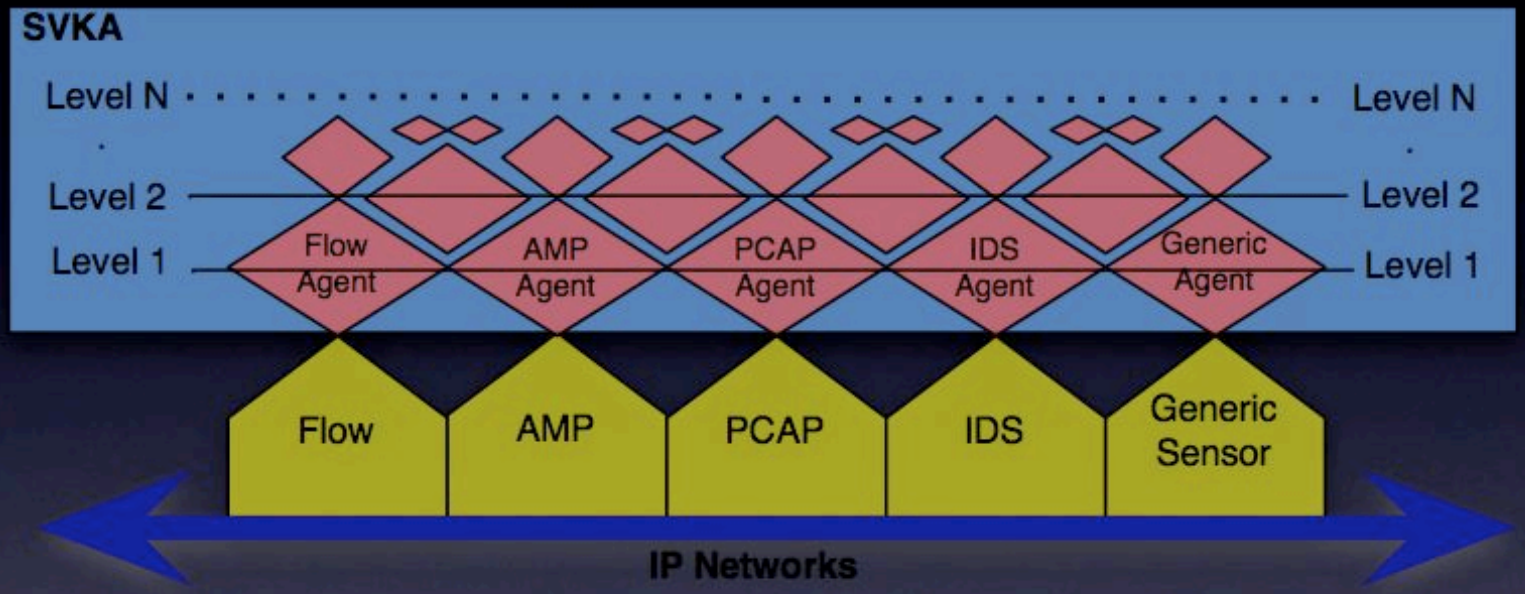
Flow Agent	consumes rwf & rwcut data
AMP Agent	queries database for most recent attributes

Flow Viewer Sensors



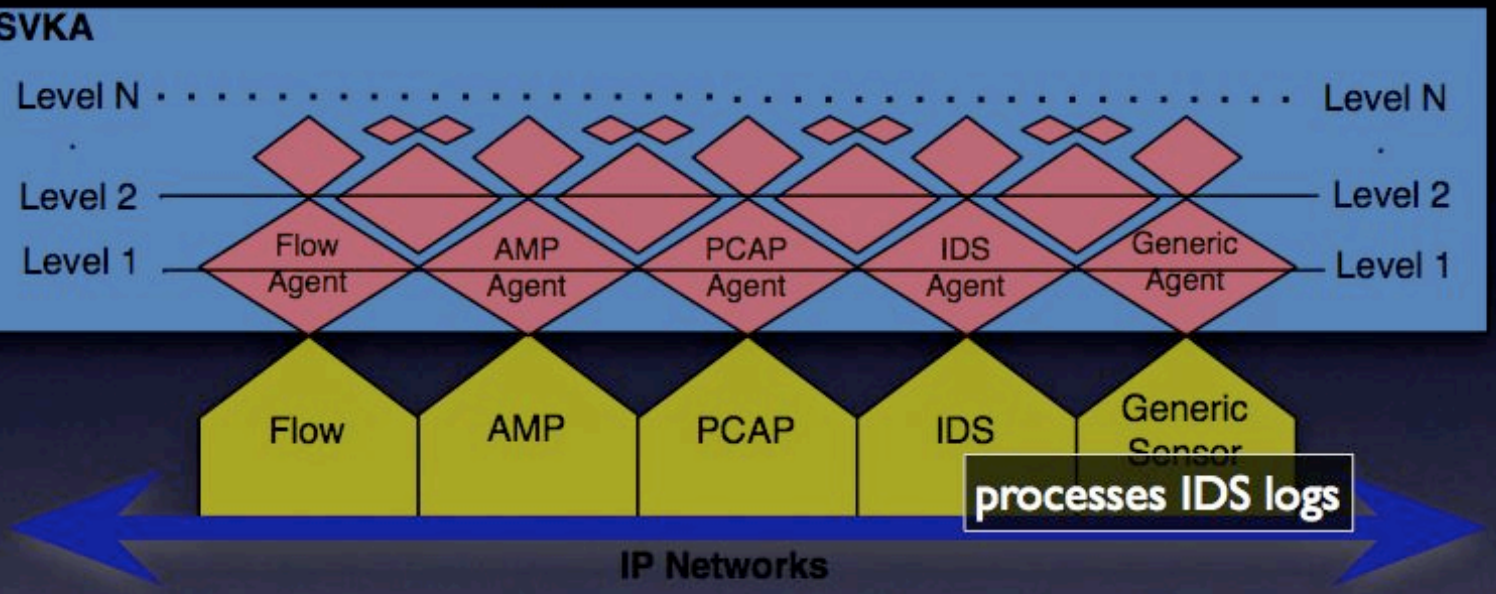
Flow Agent	consumes rwf & rwcut data
AMP Agent	queries database for most recent attributes

Flow Viewer Sensors



Flow Agent	consumes rwf & rwcut data
AMP Agent	queries database for most recent attributes
PCAP Agents	queries & reconstructs TCP sessions

Flow Viewer Sensors



Flow Agent	consumes rwf & rwcut data
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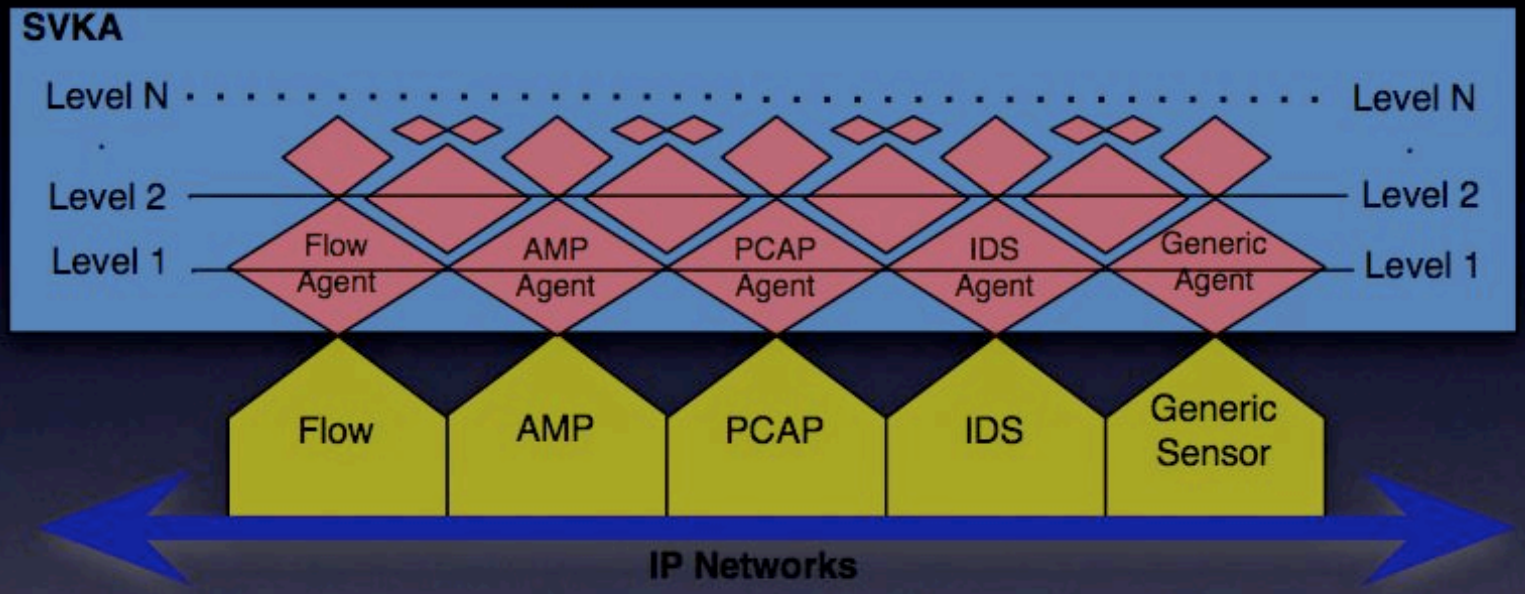
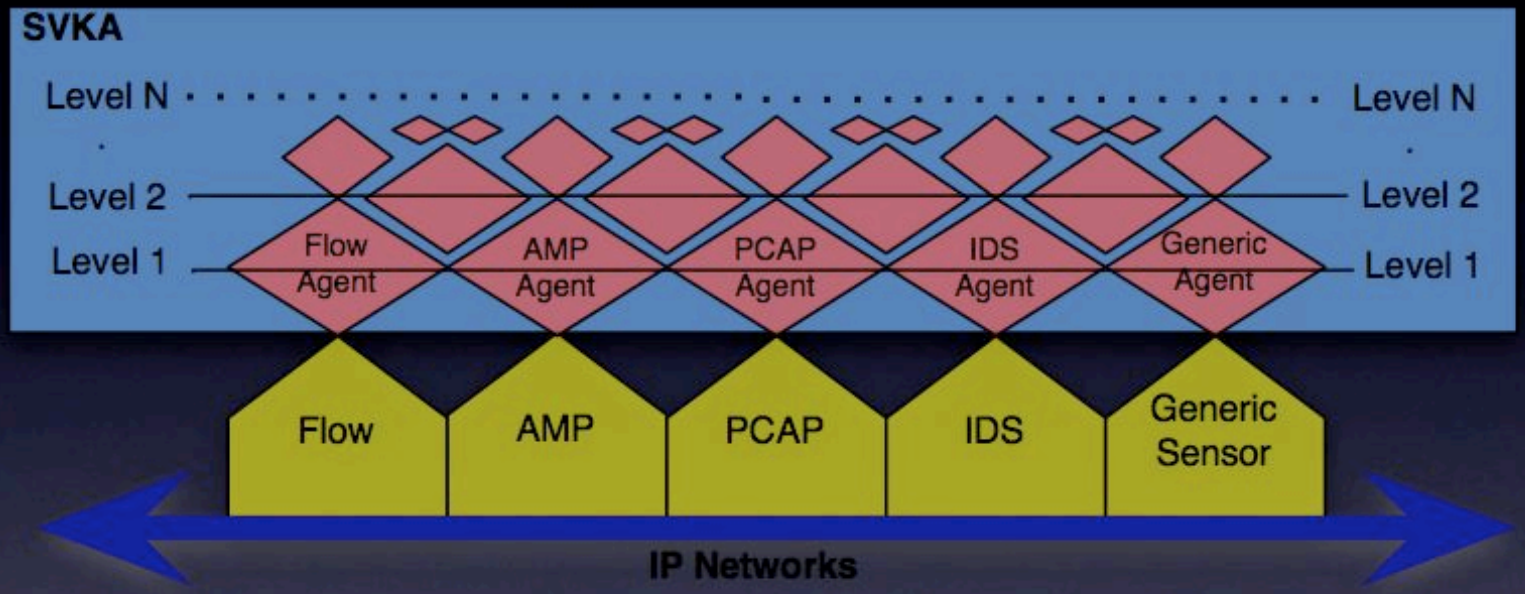
PCAP Agents	queries & reconstructs TCP sessions

Flow Viewer Sensors



Flow Agent	consumes rwf & rwcut data
AMP Agent	queries database for most recent attributes
PCAP Agents	queries & reconstructs TCP sessions
IDS Agents	processes IDS logs

Flow Viewer Sensors

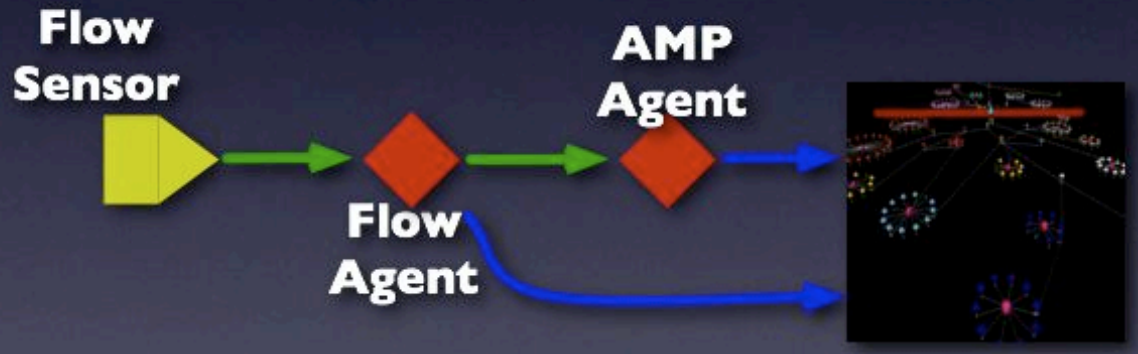


Flow Agent	consumes rwf & rwcut data ✓
AMP Agent	queries database for most recent attributes ✓
PCAP Agents	queries & reconstructs TCP sessions
IDS Agents	processes IDS logs

Flow Viewer Intelligent Agents

Flow Sensor
- Converts flow into ontology
- produces facts

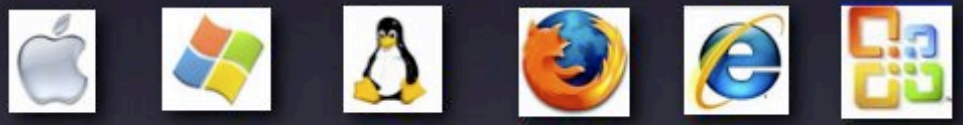
AMP Agent
- uses correlations from Flow Agent
- query made on every unique IP seen
- produces visual events



Flow Agent
- correlates records
- counts and corroborates
- produces inferences
- produces visual events

Flow Viewer Visual Language

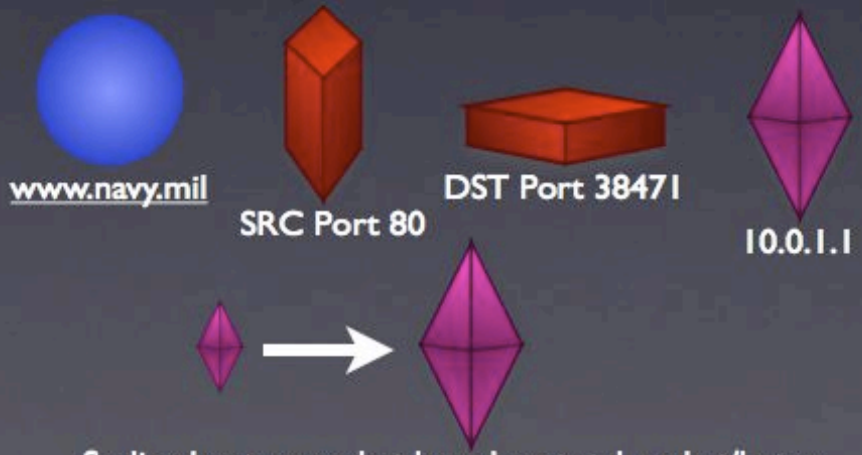
Leverage cultural knowledge



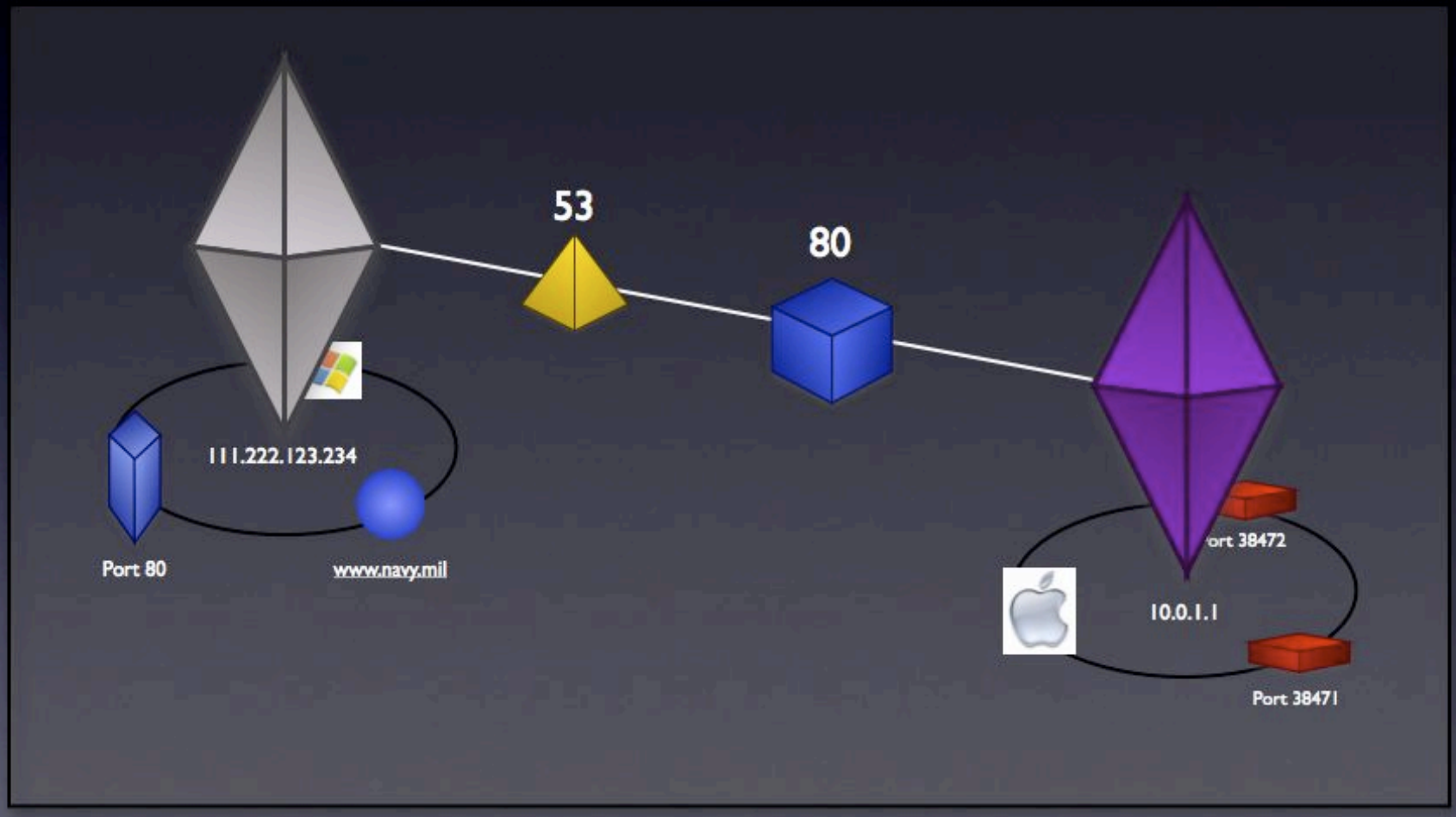
Color by ownership

USA	AF	USN
USMC	Joint	Govt
Internet		

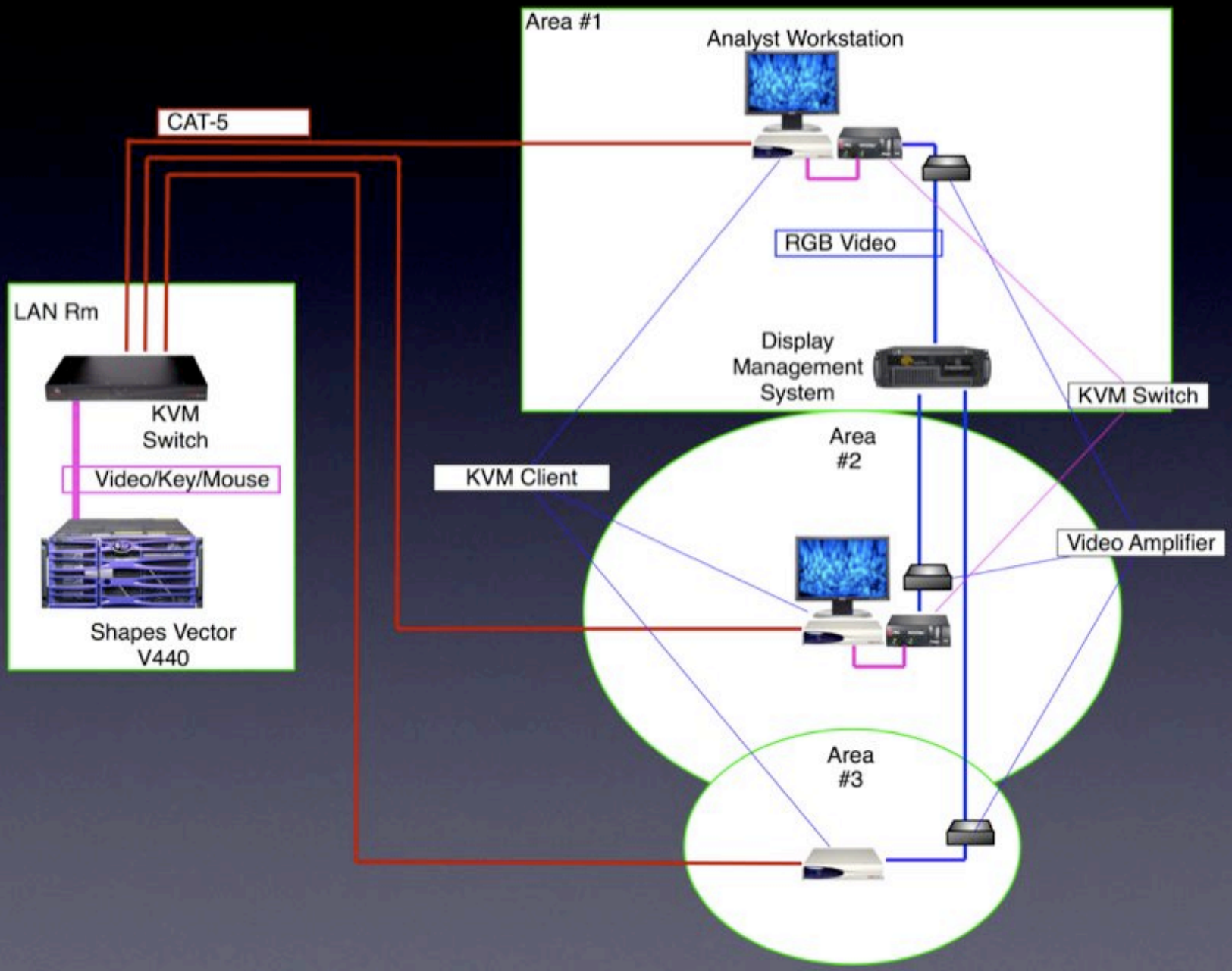
Use metaphors for abstract



Flow Viewer Visual Language



Test installation



Flow Viewer

Visualization

- **Tested** using:
  - 100-5000 nodes
  - 1M-3M flows
  - 10K-300K flows per hour
- Integrated **filtering** (rwfilter, SVKA filtering, visual filter)
- Visual ID
- **Queries**
- **Grouping** (e.g. domain, netblock, vulnerability)
- **Replay**-mode or Real-time
- Historic **visual context**
  - Replay 'on top of' known incident

Flow Viewer data prep

Include

- Incoming & outgoing
- Hub & core-to-core traffic
- Wide port ranges
- Time-span wider than the activity (minutes to hours)
- Suspect IPs and ranges

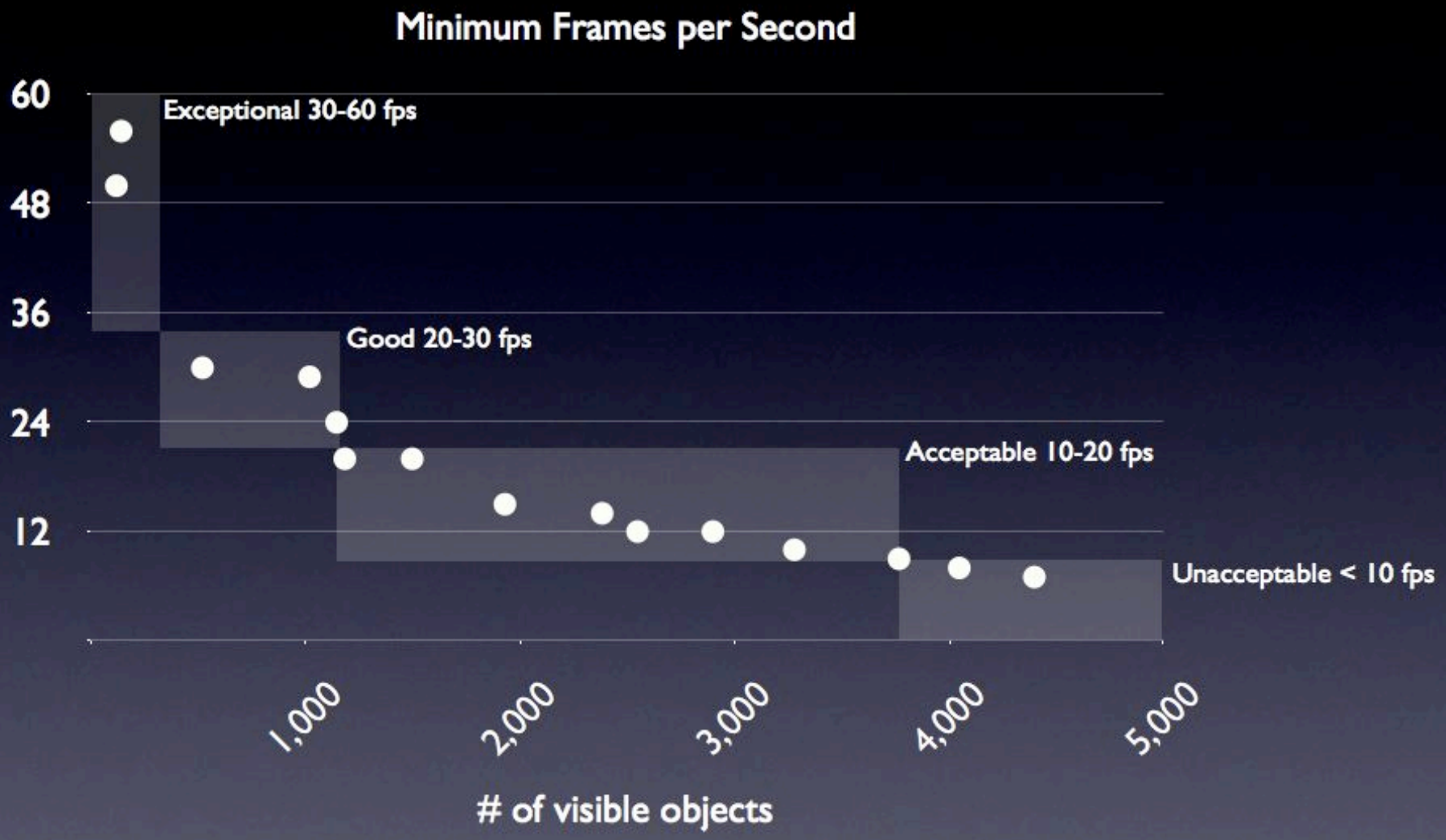
Filter

- Superfluous port traffic (e.g. 80, 53, 25)
- IPs that are unrelated to the incident

Sampling & Time

- Dense data
- Smear data across time resolution (~1 second)

Flow Viewer Performance



**Graphics performance on dual 1.5GHz SPARC SunFire v440 with Sun XVR 1200

Flow Viewer Performance

Real-time Performance	Real-time Records / Hour	Optimal playback rate
Optimal	10K-30K/hour	10X Real-time
Acceptable	40K-100K/hour	Real-time
Poor	100K-300K/hour	1/10 X Real-Time

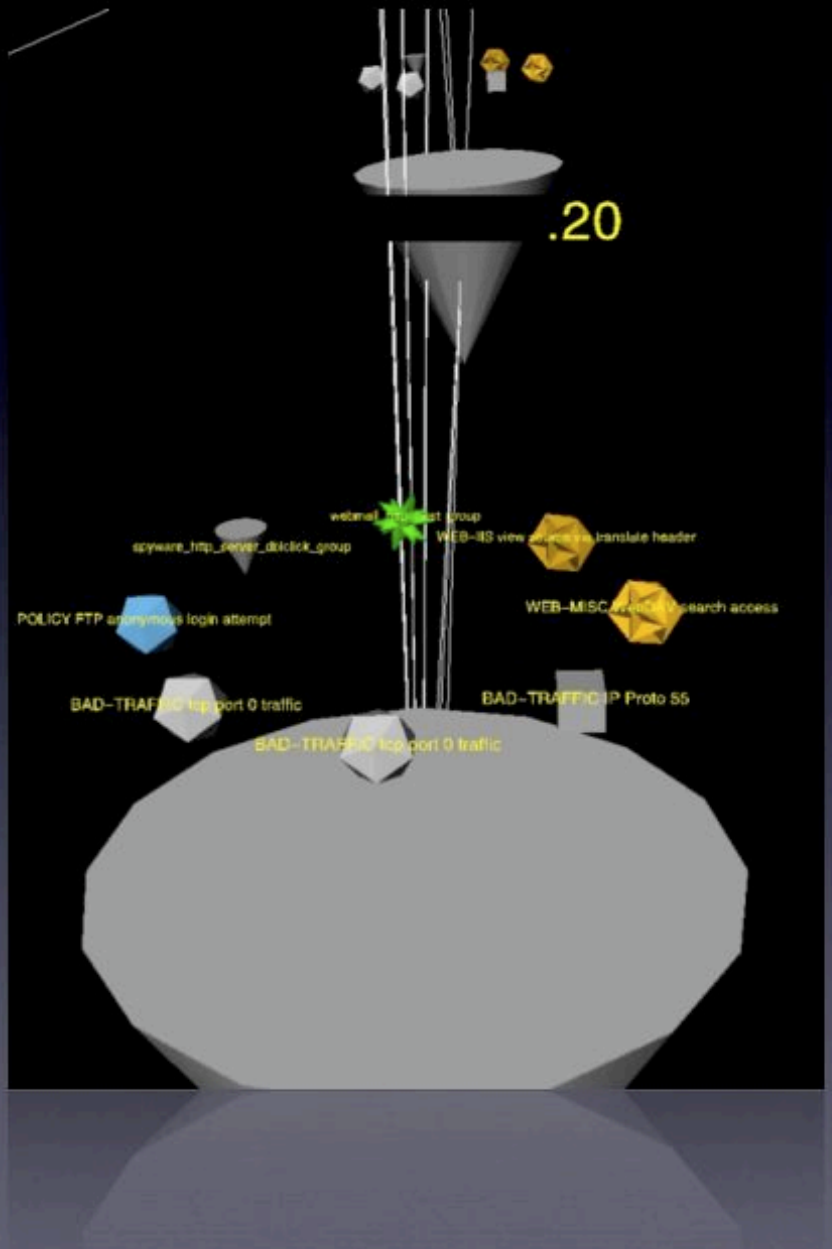
Sparse data sets can be viewed quickly
e.g. months of data in minutes

Dense data sets can be viewed slowly or filtered
e.g. seconds of data in minutes

Knowledge Depth vs Breadth

What trade-offs are we making?

- UI Feedback?
  - Haptic vs visual feedback
- Data access?
  - Random sequential access
- Training?
  - Under-learned vs over-learned
  - Tool complexity
- Meaning?
  - Visual semantic vs text
  - Intuitive/Iconic vs cryptic/coded



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Images

- Jeff Han's Multi-Touch Screen Interface, Jeff Kubina, Flickr.com, license: http://creativecommons.org/licenses/by-sa/2.0/deed.en
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SPAWAR
Systems Center
San Diego

Next Generation Tactical Situation Assessment Technology (NG-TSAT)

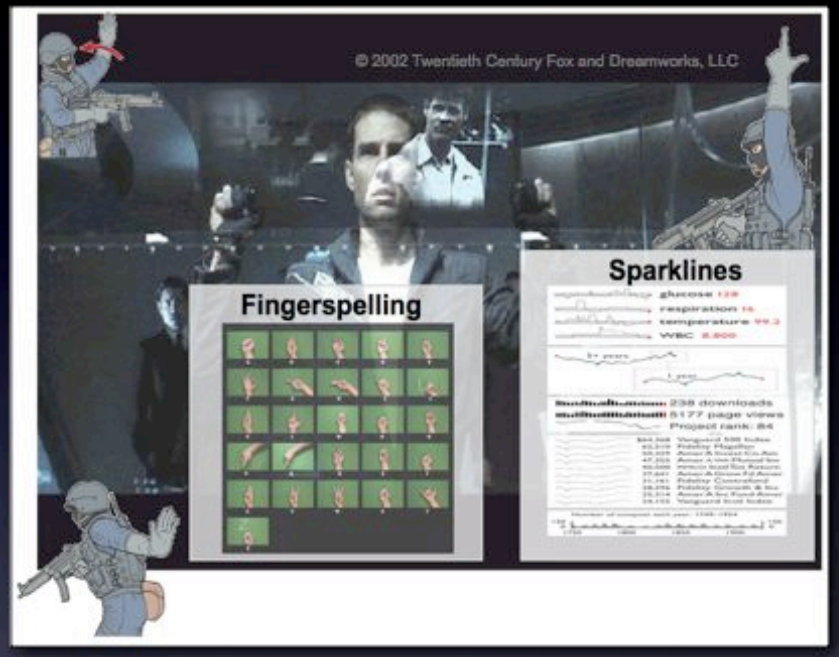
Objective: Next-generation Tactical Chat. Icon-based situation assessment (SA)language supported by wireless gesture-recognition gloves used in hostile or noisy (silence-mandated) environments

Description of Effort:

1.Linguistic Analysis: Analysis of current C² chat logs to determine speech patterns and repetitive SA concepts/themes

2. Iconic Language Development: Output of linguistic analysis determines candidate icons representing most prevalent SA "themes;" development of prototype C² iconic SA language

3. Wireless, Gesture-Recognition Gloves: Develop wireless gloves that recognize C² icons/gestures which can transmit across network to distributed warfighters (replacing keyboard input when in MOPP)



Benefits of TSAT:
Compressed Chat (25% ↓content; 50% ↓reduction in production time) for rapid SA dissemination.
Gesture-recognition in very noisy, distributed ops, or in very austere environments (e.g., the moon)
Challenges:
1. No current method or theory for chat-meaning compression; currently done in prose; computer linguistic analysis of unstructured text still neoteric.
2. Wireless gesture recognition glove technology still in infant stages of development; focused on commercial animation support, not on disciplined language support
TRL: Chat: TRL 1-2; Gesture-recognition: TRL 1-4

Major Milestones FY06:
Linguistic analysis discovery of common C² SA themes
Development of icon/symbols for candidate SA themes
Development of proof-of-concept wireless gesture-recognition glove

Period of Performance: 2007-2012

PI contact info: Dr. LorRaine Duffy, (619) 553-9222, LorRaine.Duffy@navy.mil, SSC San Diego, CA

Synaesthesia

Synaesthesia: "a neurological condition in which two or more senses are coupled."

"loud color" "sharp laugh" "bitter wind"

grapheme color synesthesia - letters or numbers are perceived as inherently colored

How many numbers contain the digit 6?

9910	9972	3292	7602	82	9054
5636	2710	1944	6330	6560	8101
5177	1955	7029	4083	4643	5710
4935	2256	1495	1025	8375	8518
80	797	2610	3008	8784	1854	2383
9728	4523	573	5914	7975	281
6664	2682	7689	7753	273	5597
799	9960	1437	4534	8601	4563
6734	647	9409	6543	4827	2398
1532					

Is this easier?

Emulating Synaesthesia

These methods can be used achieve **sequence disambiguation** and

9910	9972	3292	7602	82	9054
5636	2710	1944	6330	6560	8101
5177	1955	7029	4083	4643	5710
4935	2256	1495	1025	8375	8518
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6734	647	9409	6543	4827	2398
1532					

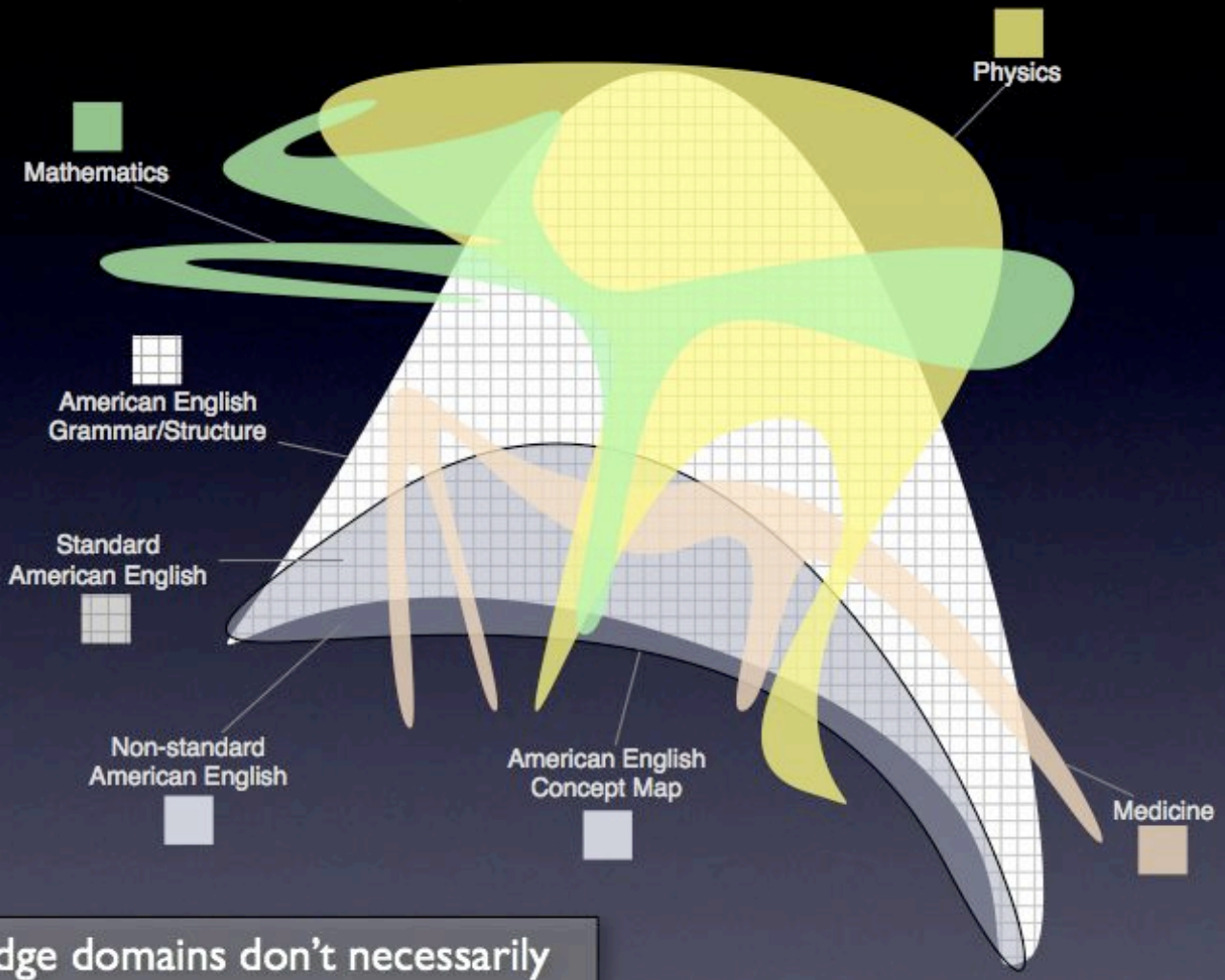
Emulating Synaesthesia

192.168.1.232
129.168.1.233

192.168.1.232
129.168.1.233

192.168.1.232
129.168.1.233

Language Domains



Cultures and knowledge domains don't necessarily use the same lexicon or even the same grammar!

How does the CND lexicon map to common language? Technical language? Military/tactical language?